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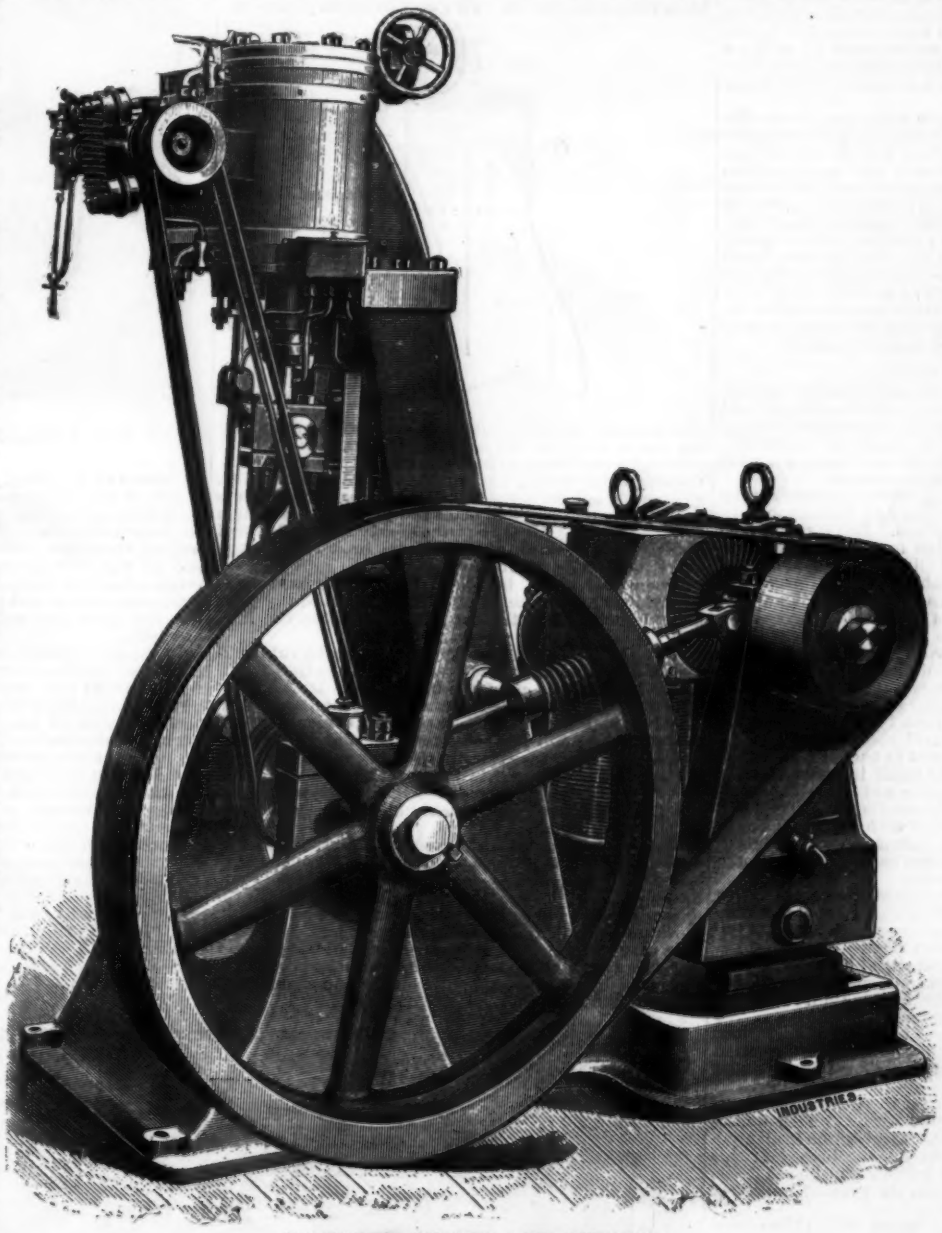
COMBINED ENGINE AND DYNAMO.

WE illustrate a combined single cylinder engine and vertical single magnet dynamo, made by King, Brown & Co., of Rosebank Iron Works, Edinburgh. This type of combined plant has been designed especially for use on board ship, where the space is limited. The whole dynamo rocks on a pin at the bottom, so that the belt can be kept taut by a thrust spring arrangement, which is clearly shown in the engraving. By this means a dynamo can be easily driven by a very short belt without any chance of slip, or of excessive tightness of the belt, or of a loose or flapping return. These combined sets are now largely used on passenger steamers.

The following are the particulars of the dynamo for 150 lamps:

Armature, Gramme wound, 9¼ in. outside diameter, 5½ in. inside; length over end plates 7 in.
Field magnets, wrought iron; circular section, 7 in. diameter; winding, 9½ in. long; section of yoke (cast iron), 7¾ in. by 8 in., or 59 square inches.
Commutator, 48 sections, 6 turns of copper strip per section.
Armature, copper, 288 turns 0·17 in. by 0·09 in.
Shunt coils, 3,124 turns of No. 18 B. W. G. on each limb.
Series coils, 21 turns on each limb.
Shunt resistance, 61 ohms; series, 0·013 ohm: armature, 0·068.
Speed, 1,020 revolutions per minute.
Electromotive force, 100 volts at all loads.
Full current, 90 amperes.

The armature is mounted on four-arm gun metal spider, keyed to the shaft. There are two brushes on each side of the commutator. All the joints in these machines are, of course, soldered with resin. A very ingenious arrangement is used in the large machines to prevent any tendency to sparking at the top and brushes, which is an evil likely to be present in large single limb Gramme machines. The fields are bored a little too large, and the armature is mounted above the center of the bore, so as to be nearer the top than the bottom pole corners. The arrangement works admirably.—*Industries.*



COMBINED ENGINE AND DYNAMO.

THE COMPARATIVE MERITS OF CONTINUOUS AND ALTERNATING CURRENTS FOR CENTRAL STATION WORKING.

WE stated some time ago, says *The Telephone*, that the question of central station lighting in Frankfort-on-the-Main, which had been decided in favor of alternating currents, had, by the municipality, been referred back to a committee appointed for the purpose. The most prominent members of the committee were the well known electrician, Prof. Dr. Kittler, of Darmstadt, and the city architect, Mr. Lindley. The final decision was again given in favor of the alternating current, and the Zipernowsky system of alternating dynamos and transformers will now be adopted.

There can be no doubt that the decision was arrived at after an impartial and most exhaustive examination of the bearings of the case, and we have repeatedly expressed our opinion that the employment of alternating currents may recommend itself in many cases from reasons of local conditions and requirements; at the same time we are more than ever convinced that, taking the two systems at their respective merits, the continuous current ought to be used wherever there are no insurmountable obstacles either of expense or of installation. This question is becoming of daily greater importance since the electric light industry has at last in this country, too, shown fresh signs of activity. We cannot do better than acquaint our readers with the opinions on this subject expressed by a German authority, Prof. Rühlmann, in the *Elektrotechnische Zeitschrift*, August, 1889.

There can be no doubt the employment of an alternating current of high potential presents the great advantage that even large towns can be supplied with electrical energy from one single station situated at some distance. The concentration effected by this system permits an economical production of energy by means of large machines; it enables the work to be carried on with a comparatively small staff, and the station to be erected in a favorable locality where coals and water are easily procured, and ashes, cinders, and condensation water can easily be got rid of. And, further, the regulation of E. M. F. presents but little difficulty in a system of alternating machines and transformers; accidental variations of current consumption are more easily balanced in a large installation than in a small one.

On the other hand, it cannot be denied that the farther remote the station is from the place of consumption, the greater the difficulties of working and of administration; further, that in large towns which are divided in two parts by wide rivers, the installation of special stations on either side of the river will be found more advantageous, and also that the inconvenience to the neighborhood arising from the establishment of a central station is not nearly so great as, for instance, the nuisance created by a railway station. In all towns of large or moderate size, provided there is no water power available, the saving effected by the alternating system in copper conductors will be more than outweighed by the cost of transformers. Even the comparative cheapness of building ground outside a large town need not be taken into serious consideration, because experience has shown that a central station can be installed in the back premises or in the yard of large warehouses or similar buildings. The first and most essential conditions to be fulfilled by a central station are:

SECURITY OF LIFE AND PROPERTY AND RELIABLE WORKING.

Now, there cannot be the least doubt that the employment of high potentials in the mains is not without danger. Unless we are prepared to suffer a large loss of energy in the transformer, we are obliged to use relatively thin insulating layers between the primary and secondary conductors. A perforation of this insulating layer, and a consequent entrance of a dangerous potential into an inhabited dwelling, may therefore take place under certain unfavorable conditions. Of the many safety devices which have been proposed for the prevention of such accidents, none has yet stood the crucial test of practical application.

However, a whole series of untoward circumstances must concur to cause a fatal accident, and the drawbacks of the alternating system on that score cannot be considered very serious. A much more serious risk seems to be that of the laborer working underneath the street, and who may, by a blow of the ax, lay bare a portion of a conductor conveying a current of high potential. It is a well known fact that such work beneath the streets is continually being carried on in large towns, and carried on by men who are totally ignorant of any danger arising from currents of high potential, and the possibility of accidents arising from this source must, therefore, not be lost sight of.

It seems to be universally recognized that economical working of central stations is impossible without

PARALLEL CONNECTION OF MACHINES OF DIFFERENT SIZE.

That this parallel connection of alternating machines of equal size and identical construction is possible, cannot be doubted; and yet it seems as if the difficulties of this connection had not completely disappeared, since Ferranti in his Deptford station does not propose to avail himself of the great advantages of the parallel arrangement. It is also known that the attempt made by Messrs. Ganz & Co., in the presence of Prof. Kittler, to connect in parallel their alternating machines at the Rome central station gave altogether unsatisfactory results. Zipernowsky, the electrical manager of Ganz & Co., in order to facilitate parallel connection, had even reduced the number of alternations to 42 per second. Mordey's experiments, too, are not altogether convincing, because they were made with two entirely identical machines. Also the frequent breakdowns at the small alternating station of Marienbad, in Bohemia, even as recently as the spring of the year, are ascribed, whether justly or not, to the difficulties encountered in the parallel connection of the Ganz alternators.

Although we are convinced that parallel connection of alternators of different size is possible, even for practical purposes, yet it must be stated that until quite recently the difficulties had not been completely overcome, and that no solution of this problem, indispensable as the solution is for central station working, has as yet been published.

LOSS OF ENERGY IN THE TRANSFORMERS.

That this loss is relatively small is well known, as is also the fact that the percentage of these losses increases when the transformers are not fully loaded. At full load the loss of energy is about six to eight per cent. (provided the primary and secondary wires are separated by an insulating layer of sufficient thickness), while this loss is increased to 15 per cent. when the transformer works at one-third of its maximum load only. Now, since all apparatus in a central station, and therefore also transformers, must be arranged in such a manner as to satisfy even a considerable additional consumption, and since the average consumption hardly amounts to 15 per cent. of the possible maximum output, the working during the greatest part of the year will be

carried on with a loss of energy compared to which the loss incurred in a continuous current system during the short periods of maximum consumption is but slight.

On the other hand, it must be admitted that the diminution of loss with increasing load in the transformer system makes up to a certain extent for the larger number of motors and dynamos required in this system to produce the same effect as with continuous currents.

A partial switching off of transformers during the time of small consumption may be feasible; whether it can be done in practice without great difficulty, with apparatus working at a potential of 2,000 volts, we have as yet no means to ascertain.

ARC LIGHTING WITH ALTERNATING CURRENT.

It has lately been asserted by interested parties that the arc light obtained with alternating currents is hardly, if at all, inferior to that obtained with continuous currents. The fact, however, that in a continuous current arc lamp the positive carbon is hollowed out in form of a crater, and that in the interior of this crater a larger surface is heated to a higher temperature, will always have this consequence, that continuous current arc lamps radiate the light, not only in a direction particularly favorable for use, but also that for the same amount of expended energy a larger quantity of light is produced by these lamps than by arc lamps driven with alternating currents. Measurements which have lately been made, and whose publication is promised at an early date, show that at equal expenditure of energy an alternating current arc lamp only gives about 66 per cent. of the mean spherical light intensity of a continuous current arc lamp. At an angle of 40° to 50°, a lamp of the latter kind gives three times as much light as an alternating current one expending the same energy.

It is possible, by fixing proper reflectors above the arc lamps and by using two carbons of different diameter, to increase the efficiency of the alternating current lamp, yet it must always be taken into consideration that to obtain the same light effect with this latter kind of lamp as with continuous current ones about 30 per cent. more of electrical energy must be expended.

Taking the case of the Berlin stations, where nearly one-half, and of the Elberfeld one, where about one-third of the energy produced is consumed in arc lamps, this inferiority of the alternating current is of very considerable account in calculating the size of the installation and the working expenses, and consequently also in the prices to be charged to the consumer.

ELECTRO MOTORS.

The present tendency in Germany seems to be that municipal bodies erect their own central stations, and work them, not so much for making any profit out of them as for conferring a benefit upon the consumer, and in these schemes the employment of electro motors is a most important point to be considered.

That synchronous alternating current motors can be worked with equally high efficiency as continuous current ones can no longer be doubted. But synchronous motors require special apparatus for starting, because the synchronizing tendency of all alternating machines will only prevail after the number of their alternations has become nearly equal. This must naturally entail a relatively greater complexity of alternating current motors. And further, we must not forget that synchronism of very small electro motors would lead to a very high speed of rotation, quite inadmissible in practice, and also that electro motors of constant speed are wholly impracticable for a large number of applications (lifts, for instance). But it will be found that it is exactly this possibility of driving *small motors* of different kinds which has to be considered in the first instance. It is a well-known fact that for small industries steam and gas motors of one to six horse power are the most extensively used. The favorable results which Tesla and Ganz & Co. have lately obtained with alternating current motors of 50 and 30 horse power cannot be considered as proving that small motors can be driven economically with alternating currents.

And again, if we are told that Prof. Kittler has seen a Ganz motor working at Buda-Pesth, and has convinced himself by his own measurements that at full load 78 per cent. and at half load 74 per cent. of the electrical energy expended were converted into mechanical energy, we must not forget that a good continuous current motor under similar conditions would have shown an efficiency of about 90 per cent.

In many applications it would also prove a serious drawback that synchronous alternating motors when overdriven, be it for a short time only, stop altogether and have to be started afresh.

It is a very significant fact that the internal arrangement of alternating motors has hitherto been kept a profound secret, although patent legislation in all civilized countries sufficiently protects the inventor; this points to the conclusion that it is not considered desirable to expose the apparatus in its present imperfect condition to scientific criticism.

In short, even admitting as correct all that has been stated by uninterested and competent authorities in favor of the alternating motor, it cannot be denied that the alternating motor is vastly inferior to the continuous motor both in efficiency and in general adaptability, and that small motors of the former kind do not yet exist in practice at all.

It is quite a different thing to work out a new mode of application of electricity on paper and to apply it economically for industrial purposes; a long gap lies between the two, which generally requires a good deal of time and money in filling up.

The working of electric tramways with alternating currents, which has been proposed by the Westinghouse Co., has not, to our knowledge, met with any practical result as yet. We have at present not even the means of judging of the possibility of such an installation.

CHEMICAL EFFECTS OF ALTERNATING CURRENTS.

It is a well-known fact that chemical effect cannot be practically obtained with alternating currents. We, however, do not attach so much importance to this drawback as is done by many other electricians. The employment of accumulators in central stations undoubtedly presents many advantages, but is not, according to Mr. Ruhlmann, of paramount importance yet. In districts where there is a constant supply of electrical energy, the want of accumulators will not make itself felt to any large degree; only in special cases the impossibility of charging accumulators from a central station will appear as a distinct drawback of the alternating system.

Especially for theaters and similar localities where large numbers congregate, the employment of accumulators for lighting in case of accidents ought sooner or later to be made compulsory by law, and it is therefore only natural that in a town possessing a central station the accumulators should be charged from the leads of the network. Further, for tramways to distant suburbs accumulators will probably find extensive employment, and it is desirable to connect the charging stations with the central station.

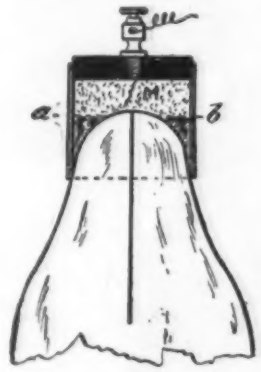
HOW TO REPAIR GEISSLER TUBES.

By GEORGE T. HANCHETT.

IT often happens in the course of experimenting with small incandescent lamps and Geissler tubes, that the small platinum loops are broken off short in the glass, and to connect any wires to them by any means is a difficult job, requiring more skill and patience than some persons possess.

To repair such tubes and lamps, the following materials are needed. First, some stick shellac, second, a piece of brass tube that will just fit over the tube or lamp and admit a suitable portion of the glass, third, a small vial of quicksilver, and lastly some No. 20 uncovered copper wire.

The first thing to be done is to coat the inside of the brass tube with shellac. This may be accomplished by



placing a few pieces of the shella in the tube and melting them with the flame of an alcohol lamp. Next melt some shellac in a tin dish and coat the end of the vacuum tube by dipping it in the melted substance. It will readily adhere to the glass. Then chip a hole where the wire was broken and place the prepared brass tube over the whole. Heat the tube gently in the flame of a spirit lamp, taking care that the broken wire is as nearly central as possible.

When cool it will be found that the brass tube is firmly attached to the glass. Now very carefully pour melted shellac into the tube until it reaches the line, *a*, *b*.

While this is cooling, make a plug of hard rubber if possible or some hard, fine-grained wood, so that it will nicely fit into the end of the brass tube. Drill a small hole in the center, and insert a small pole cup, which may be obtained for a few cents of any dealer. Attach a wire to the cup in such a manner that it will protrude beyond on the opposite side, and smear that side with melted shellac. Now take up the tube, and holding the plug in the open end, heat gently in the alcohol flame. The shellac quickly melts and fastens the plug firmly in place.

Do this heating as quickly as possible, and as soon as through hold the work in an upright position, so as to leave the point, X, uncovered. Remove the pole cup and wire, and through the hole pour mercury till the space, M M, is filled, and replace cup and wire. The work may now be polished and varnished.

In case the article to be mended is a lamp, a fine copper wire should be attached to the unbroken end and the lamp and wire coated with shellac and a small hole chipped above the broken wire as before.

Two binding posts will be required in the plug, but otherwise the work will be essentially the same.

TELEPHONY AT STOCKHOLM.

THE Almanna Telephone Co., of Stockholm, has a telephone service at present established in that city which presents several points of interest. This installation dates back to 1883, but has undergone very important modifications. The telephone apparatus employed are those of the Ericsson Co., represented in Fig. 1. The transmitter is fixed to the upper part of a standard resting upon a base in which is placed the call bell; and the receiver is at the side. This transmitter, B, consists of a very flexible diaphragm, *s*, to the center of which is fixed a small carbon disk, and opposite the latter there is a platinum wire that establishes a contact.

This wire is carried by a metallic cylinder which is fitted to the extremity of a screw with a movable head. The platinum wire is pressed against the carbon disk

FIG. 1.—ERICSSON TELEPHONE.

by means of a spring, *f*, placed in the interior. The object of this arrangement is to permit of a very easy regulation and, at the same time, a very sensitive one, through a slight motion of the screw head. The subscriber, therefore, can regulate his apparatus for himself at will, and adapt it to his requirements. The other mounting arrangements of the apparatus with induction coils do not perceptibly differ from those ordinarily employed, and we shall, therefore, not speak of them.

In the early period of the installation, the company contented itself with setting up three offices, one at the south, one at the north, and one in the center of the city. These offices at first were operated only during certain hours of the day; then gradually, day and night, continuously. Fig. 2 shows the internal aspect of one of these offices, the northern one. A series of high-backed desks are placed alongside of each other. On the backs of these are placed the annunciators corresponding to each of the subscribers. Here, too, is placed the transmitter, which is thus on a level with the mouth of the employe, who can telephone while seated. Finally, upon the horizontal plane are arranged the commutators for effecting all the necessary changes of direction. All these arrangements do not differ essentially from those hitherto adopted, but they are interesting by reason of their simplicity and convenience. It will be noticed in the engraving that these offices are still lighted by gas; but it is very probable that the latter will be replaced by the electric light.

FIG. 2.—CENTRAL TELEPHONE OFFICE, STOCKHOLM.

Such were the three telephone stations that did service until 1886. As the number of subscribers was increasing at this epoch, it was decided to establish a larger number of district stations and to connect all of them with the northern office. As the old premises had become inadequate, a new building was erected. Upon the roof of this edifice there is an immense tower formed of a series of juxtaposed and intercrossed iron bars. To these iron rods are fixed 8,000 porcelain insulators, on which are strung phosphor-bronze wires one millimeter in diameter. All the circuits, in fact, are aerial in this new arrangement.

After the building was finished all the circuits were arranged, and it was necessary to replace the old station by the new one. The work was effected at night in four hours and seventeen minutes. We give the exact figure because it merits being mentioned. The communications which, on the preceding evening, were given by the small northern station, were capable of being made the next morning by the new station, the service having been interrupted for but a few hours.

Since that epoch, the telephone communications have not ceased to operate regularly, and the number of subscribers has ever continued increasing. In 1886, the number was 3,600, and the number of transmissions amounted to 5,802,063 during the year, say 18,222 per day, or between 5 and 6 per subscriber and per day. The total length of the circuits was 5,287 kilometers (3,672 miles). In 1887, the number of subscribers was 4,015, and the number of transmissions for the year was 6,462,548, say 20,590 per day, or between 5 and 6 per subscriber and per day. The length of the circuits was 7,058 kilometers (4,235 miles). On the first of October, 1888, there were 4,300 subscribers, 6,383,431 transmissions, and between 6 and 7 transmissions per subscriber. The number of telephonists employed does not exceed ninety.

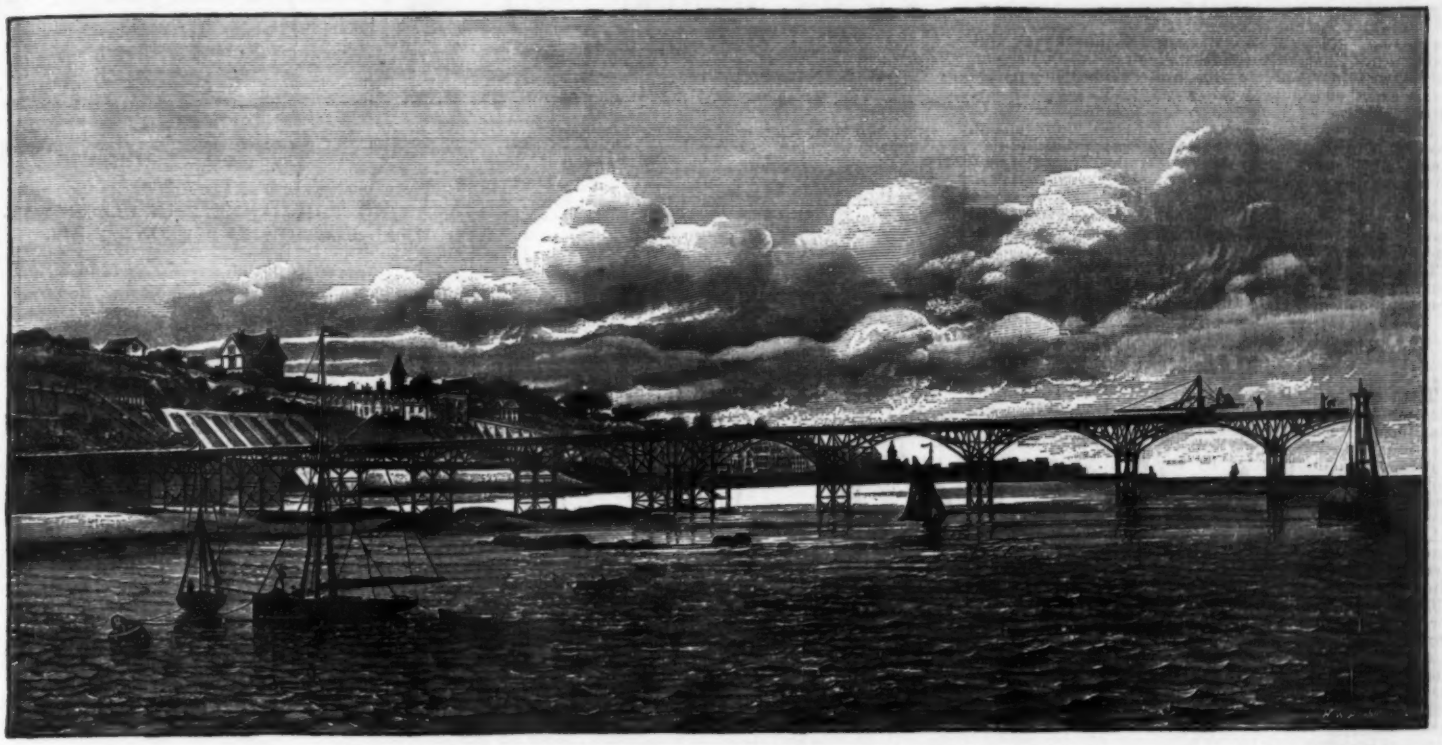
It must not be thought, however, that foreign countries are the only ones to advance telephony. Progress is also very rapid in France. On the 31st of December, 1888, the number of subscribers in Paris was 6,130 against 5,274 in 1887, say an increase of 846; at Algiers, 94 against 89; at Bordeaux, 440 (404 in 1887); at Havre, 275 against 235; at Marseilles, 449 against 400; at Nancy, 114 (106 in 1887); at Rouen, 146 against 119; and at St. Etienne, 110 against 108. The number of subscribers is continually increasing in almost all the cities. A very happy conclusion may be drawn therefrom in favor of the future developments of telephony between cities and even between foreign countries. Who can foresee the wonders that the future has in store for us?—*La Nature.*

A LARGE STATIONARY BOILER.

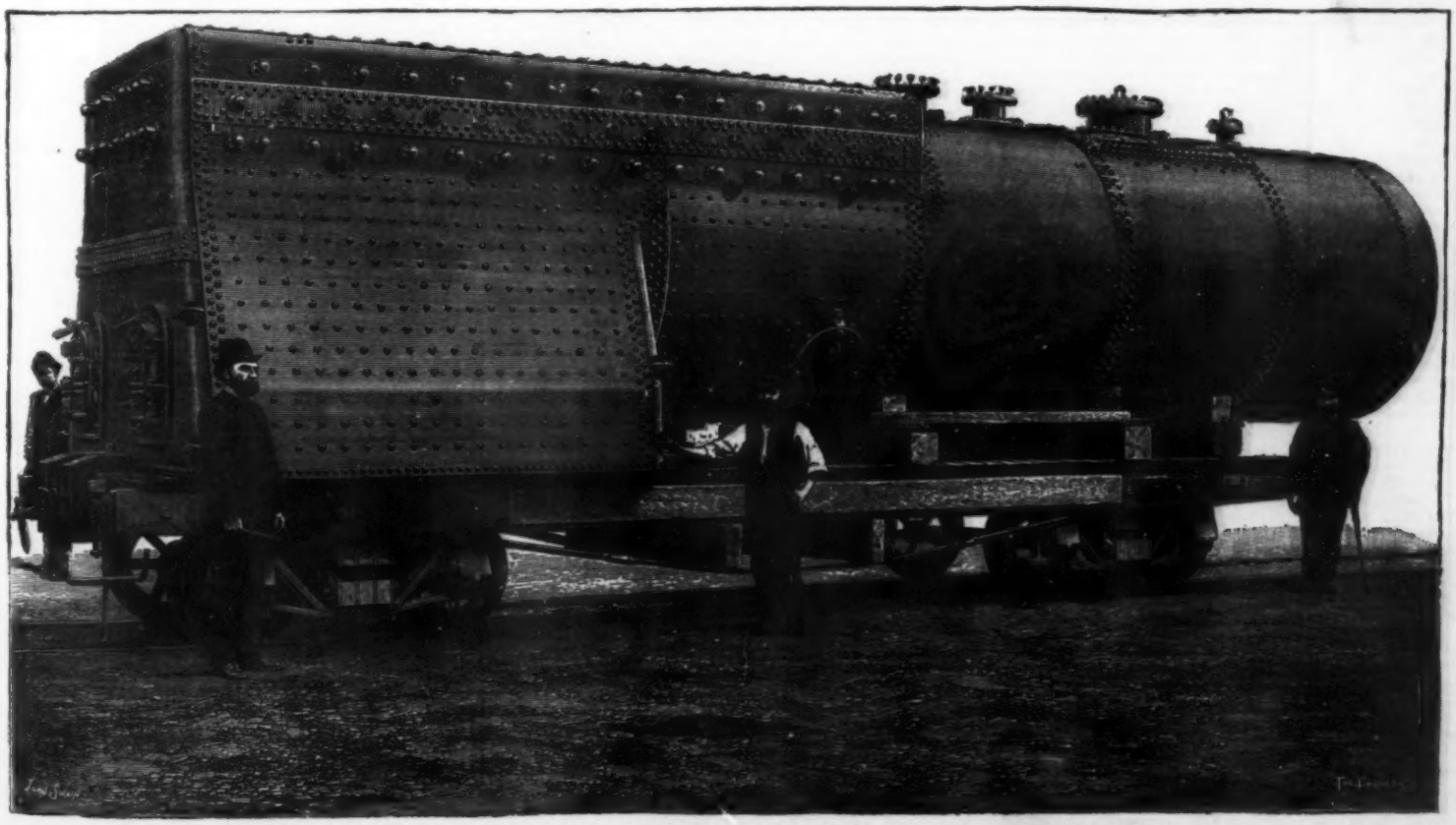
OUR engraving shows a boiler built by Messrs. J. P. Morris & Co., of Port Richmond Iron Works, Philadelphia. It is one of several constructed for the Calumet and Hecla Mining Company, Calumet, Michigan, and was designed by Mr. E. D. Leavitt, Jr. Our engraving is from the *Engineer*. It is said to be the largest stationary boiler in the United States, and in design and workmanship the entire battery is not only illustrative of the progress made in modern boiler making, but of the work that can be accomplished with the aid of perfected modern appliances. One of these boilers is now supplying ample steam for a compound engine of 750 indicated horse power, and it is estimated that with a pressure of 180 lb. a triple expansion engine will get 1,000 horse power out of it. The boiler illustrated is 34 ft. 4 in. long, 7 ft. 6 in. in diameter, 9 ft. 2⅛ in. wide, and 9 ft. 2⅛ in. high. It contains 199 tubes of 3 in. diameter and 10 ft. long, and its total weight is thirty-three tons.

TROUVILLE PIER.

THE pier is being constructed for the Trouville Pier and Steamboat Company, Limited, to the designs of Professor Alexander B. W. Kennedy, F.R.S., by the Darlington Wagon and Engineering Company, of Darlington. Its total length, says *Engineering*, is to be about 1,260 ft., and at present about 950 ft. are constructed. The engraving herewith which is, from a photograph taken on May 17 last, only shows the first 550 ft., but is quite sufficient to indicate the construction of the rest. The pier is carried on a series of braced arches of 50 ft. span, the structure consisting of three sets of parallel arches, as shown in the engraving. The piles are of quadrant iron, and are simply driven into the clay, which underlies a thin layer of sand. The pier is made up of (starting from the shore end) (1) six spans of 50 ft. each, (2) one staircase span of 15 ft., (3) six spans of 50 ft. each, (4) second staircase span of 15 ft., (5) eight spans of 50 ft. each, (6) a principal staircase span of 15 ft., connected with the shore ends of timber landing stages, of which there is to be one on



NEW PROMENADE AND LANDING PIER, TROUVILLE.



THE LARGEST STATIONARY BOILER IN THE UNITED STATES.

each side of the pier spreading outward diagonally. (7) three more spans of 50 ft., (8) a large head with a deck area 80 ft. in length and 150 ft. in breadth, carrying a concert hall and pavilion 40 ft. by 104 ft.

The shore span and each of the staircase spans is 51 ft. wide. The remainder of the pier is 31 ft. wide. Seats run practically the whole length along each side of the deck. The columns are 12 ft. apart transversely, so that the deck overhangs the outer arches by 3 ft. 6 in. on each side. The arches and all their bracing are made of mild steel.

The pier starts from the Digue at the east end of Trouville, not far from the Hotel des Roches Noires. It has been made long enough to give at the outer part of the landing stages about three meters depth of water at low water spring tides, so that the steamers from Havre can embark and disembark passengers and goods at all times of the tide, instead of as at present only near the top of the tide, and even then only by going right round into the harbor. The importance of this matter to Normandy will be understood when it is remembered that at present there is no means of crossing the Seine by railway bridge nearer than Rouen, about sixty miles from Havre. Thus a journey of about 120 miles has to be performed to go from Havre even to the nearest point of Normandy, six or seven miles away. The Trouville Pier Company intend to have the pier open for steamboat traffic and for promenade next season.

This pier is, it is believed, the first which has been constructed on a purely arched design, and certainly the appearance of the arches is exceedingly good.

SUBMARINE WORKS OF THE OUTER PORT OF LA PALLICE.

THE construction of the outer port of La Pallice (La Rochelle) has given rise to a series of interesting submarine operations, executed by Messrs. Zschokke & Terrier, by means of new apparatus and processes.

A beginning was made by the construction of the north and south jetties, which were connected with each other by a batardeau 984 feet in length. The inclosure thus formed was pumped dry and excavated. It then remained to execute the submarine works outside of this inclosure. The south jetty had to be prolonged 1,000 feet beyond its point of junction with the batardeau. The north jetty had to be prolonged 410 feet, and submarine blasting had to be done between these two jetties and in the channel of the offing.

Submarine Jetties.—The system of sunken caissons masoned upon the ceiling in the interior of the batardeaus was absolutely impracticable, seeing that the jetties were to be constructed in the offing, without protection against the sea and storms; so the contractors had recourse to the principle of the movable caissons that Mr. Zschokke had previously employed for the foundations of the Painbœuf wharves. They were thus enabled to lay 24 submarine blocks, of 1,720 square feet, and connect them by small masonry arches. For the execution of this work, two movable iron caissons were constructed. Each of these was 72 feet in length by 33 in width, and had two compartments, one above the other. The lower compartment, 6 feet in height, was the working chamber, and the upper one, 7 feet in height, was a balancing chamber, and completely dry. Upon the top of the latter there was an iron scaffolding 26 feet in height that supported a 52 x 15 foot platform. This latter communicated with the working chamber through four vertical wells, two of which were provided with two air locks for the passage of the workmen, and with lateral locks of less size for the introduction of mortar; while the two other wells, designed for the extraction of rubbish and the introduction of ashlar, were surmounted with automatic locks. Over these locks were mounted Schmid compressed air motors, designed to actuate the windlasses, and supplied by blowing apparatus established upon *terra firma*.

Each caisson weighed 110 tons and carried upon the partitions a permanent load of masonry of 220 tons. The caisson, which was mounted on the shore, was let down at low tide to the foot of an inclined plane. It was set afloat at the succeeding high tide and towed

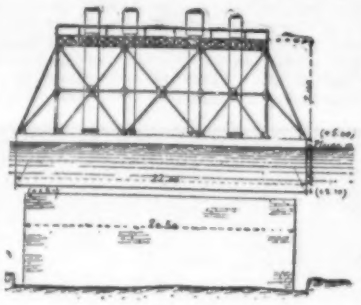


FIG. 3.—CAISSON REMOVED FROM THE BLOCK.

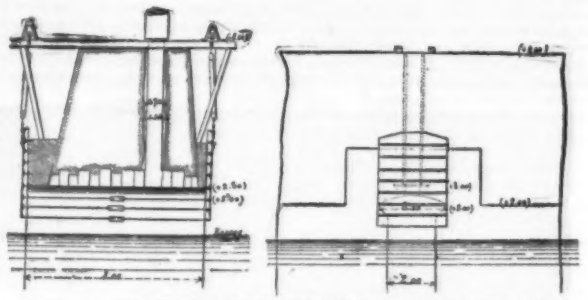


FIG. 4.—PUTTING THE PANNELS IN PLACE—LONGITUDINAL SECTION AND FRONT VIEW.

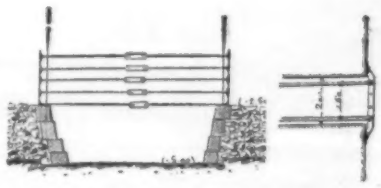


FIG. 5.—MASONRY OF THE WALLS AT THE BOTTOM.

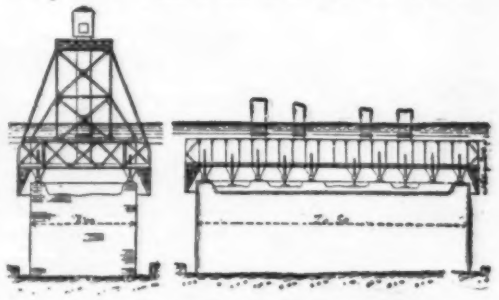


FIG. 6.—FORMATION OF THE BLOCKS—LIFTING THE CAISSON WITH SCREW JACKS.

to the place where it was to be sunk. After the balancing chamber had been filled with air, and the working chamber with water, the draught was 11 feet. The sinking was effected as follows: The caisson was connected with the jetty in the rear, and with five firmly anchored buoys by hawsers th ' passed over pulleys fixed to the top and ended at windlasses placed on the

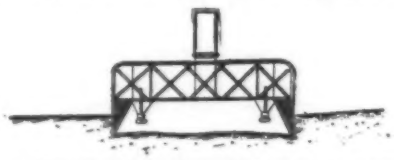


FIG. 2.—TRANSVERSE SECTION OF A CAISSON IN THE PROCESS OF BEING SUNK.

platform. Upon acting on the windlasses, it was possible to regulate the position of the apparatus and align it upon the part of the jetty already constructed. If it was a question of the first blocks, where the height of the water above the bottom was less at low tide than the draught of the floating caisson, the latter was allowed to descend with the sea, and, as soon as it touched bottom, the balancing chamber was filled with water, so that the caisson could not ascend with the rising tide. If, on the contrary, it was a question of blocks placed more toward the open sea, where the caisson could not touch bottom at low tide, the valves were opened that allowed water to enter the balancing chamber, and the caisson sunk.

In order to balance the sub-pressure of 400 tons produced by the introduction of compressed air into the working chamber, the caisson was supercharged by about 220 tons with pig iron arranged upon the top. The first work performed in the caisson consisted in leveling it by excavating under the highest parts of the edge, and then removing the superficial strata of the bottom until the limestone was reached on which the block was to rest.

For lifting the caisson during the progress of the work, 24 screw jacks were used, the steel rods of which were 6 feet in length and 4 inches in diameter. These jacks were maneuvered by 48 men. The action of these jacks was seconded by that of 6 hydraulic jacks of 30 tons, maneuvered by 12 men.

Work on the masonry was carried on for 8 hours out of the 24. The sixteen hours was consumed in the lifting of the caisson and the supplying of material, for the work was kept up day and night. Fifteen masons, served by helpers, executed about 180 cubic feet a day.

Rough water often interrupted the work, and these interruptions sometimes lasted several weeks. The caisson was then lowered upon four large masonry pillars elevated upon the block up to the ceiling.

When the block was at the level + 6 feet, it was necessary to disengage the caisson, in order to move it toward a new point of operations. The pig iron was

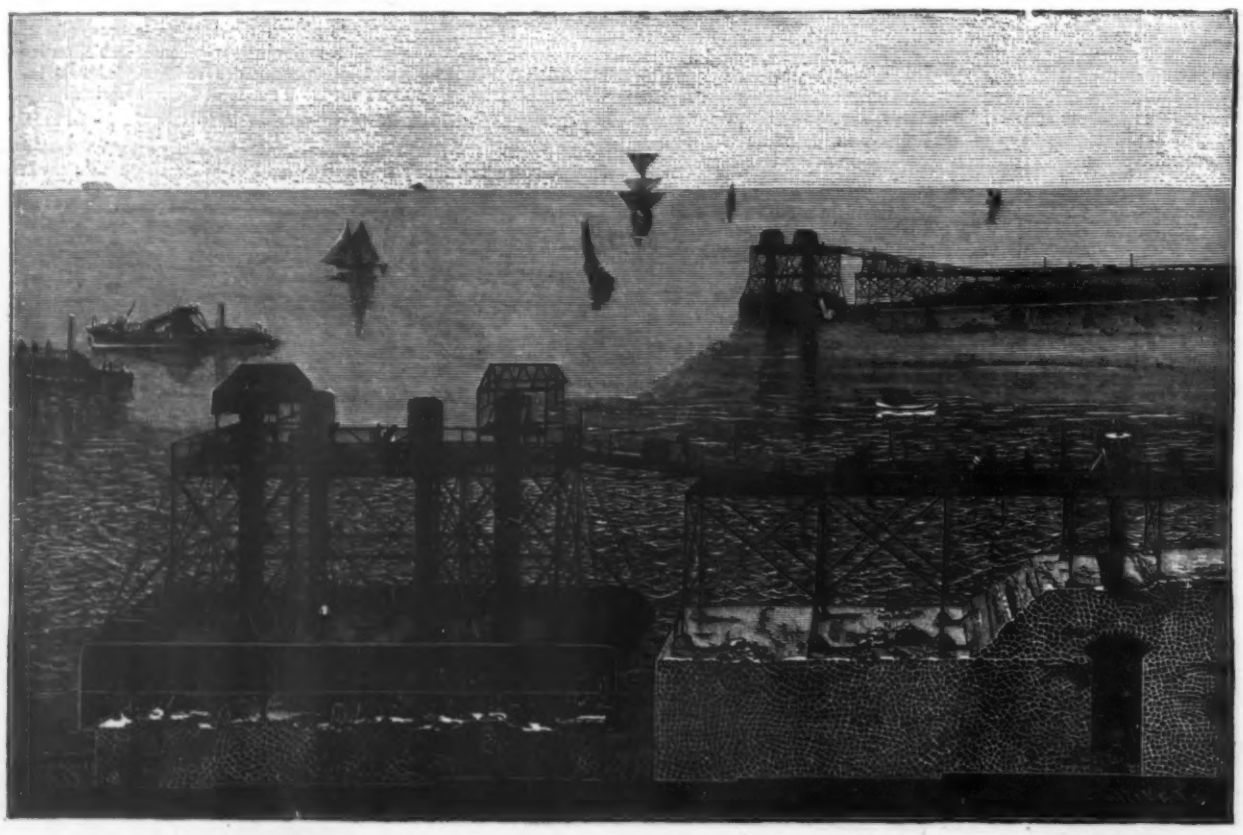


FIG. 1.—CONSTRUCTION OF THE JETTIES AT THE PORT OF LA PALLICE.

then removed, the six hawsers were replaced at low tide, and the water was pumped from the balancing chamber. The caisson thus lightened rose with the tide, and was then moved to the new point of operations by means of the windlasses and hawsers.

When the sea was calm the operation was easy, but in stormy weather it was difficult. It would even have been dangerous had a sudden change of weather caught the floating caisson at the moment at which it could be neither disengaged from the block nor let down again upon the latter.

The caisson was reached through the jetty, the building up of which followed the construction of the foundation block about 150 feet to the rear. This space was spanned by a footbridge resting upon a solid framework whose supports were U irons sealed into the masonry. When the difference between the constant level of the bridge and the variable level of the platform became too great, they were connected by an oaken flooring provided with rails upon which the cars were mounted by means of a compressed air windlass.

Submarine Blasting.—The process of removing the rock from the outer port and the channel consisted in founding, between the wing wall of the north jetty and the twelfth block of the south one, four supplementary blocks across the entrance channel of the outer port, in joining these blocks by solid masonry so as to form a second batardeau, in pumping out this new inclosure, and after demolishing the first batardeau, in removing the 4,200,000 cubic feet of the second inclosure by the usual processes.

In order to assure of the tightness of the inclosing walls, it was necessary to close up, under water, the openings left free under the arches of the blocks. This was one of the most serious difficulties that was encountered. To overcome it, each of these intervals was converted into a genuine little caisson, whose sides were formed of the two blocks, the junction arch, and two metallic side panels. These panels were formed of frames 16x20 inches in height made of iron plate and angle irons which were assembled with bolts and provided with a rubber joint. In each arch and in the masonry up to the level +25 ft., an aperture 28 inches in diameter had been left. At this level, the construction of the jetty was arrested and two windlasses were placed in position to maneuver the panels. The constituent frames of these panels were curved at their extremities and rested upon the longitudinal sides of the two blocks. The upper frame was also curved upon its longitudinal upper face, and completed the closing of the masonry above the arch. Screw tie bars bolted to the angle were screwed to draw together and fasten the two panels. The two panels to be placed face to face were composed in each case of a number of frames, determined by the vertical distance of the intrados of the arch from the stratum of detritus obstructing the bottom of the space to be filled. Thus prepared, they were suspended from the windlass and let down at low tide. They were held in the first place at such a height that the angle irons of the lower frames might place themselves a little below the intrados of the arches and a little above low water. Then the tie bars were placed in position and tightened slightly. These arrangements having been made, the next low tide was awaited, and then the tie bars of the upper frames were tightened. A tight joint was made with clay, quick-setting cement, and oakum between these first frames and the sides of the blocks, and then the water was forced back by means of compressed air, and in measure as the lower frames were exposed, their tie bars were tightened and the joints were luted.

When a tight working chamber had thus been obtained as far as to the surface of the mixture of rubber and clay in the bottom of the space to be filled up, there were constructed, under the lower angle irons of the panels, small walls 20 inches in height, and by means of compressed air a clearing was made to the base of these walls. Then two others were constructed under the preceding, and so on, step by step, until the rock was reached.

The success of this process was complete, and the removal of the rock was successfully effected in the open air without any infiltration through the masoned inclosure.

As for the removal of about 350,000 cubic feet of rock, that had to be done toward the open sea, under water, there were used for this work the Beaumont rotary diamond drills, revolving at the rate of 300 revolutions per minute and boring holes that were afterward filled with a tin canister containing 4½ lb. of dynamite. These drills, as well as the engines that actuated them, were mounted upon a boat. The charge was exploded by electricity, and a dredger removed the debris and dumped them in the open sea.—*Le Genie Civil.*

SIBLEY COLLEGE LECTURES.—1889–90.

BY THE CORNELL UNIVERSITY NON-RESIDENT LECTURERS IN MECHANICAL ENGINEERING.

I.—THE ADAPTATION OF THE STEAM MACHINERY IN MARINE CONSTRUCTION.

By CHAS. E. EMERY, Ph.D., N. Y. City.

THE title of the lecture embraces a field which it will be impossible to cover at one session, but we will endeavor to discuss the general principles involved and to apply the same by comparing the performances of sea-going vessels of different sizes, operating under different conditions.

The duty to be performed by the steamer, as well as the general size and type of vessel and its distinguishing features, such as the rig, speed, general appearance and arrangement, will usually be settled by outside considerations, but the desired requirements should be first checked by the performances of other vessels, to ascertain by general comparison of sizes, speeds, and carrying capacities if it is probable that the results can be obtained with the size of vessel proposed. It may be that the engineer will find it necessary to settle preliminarily with the naval architect and owner certain questions as to the size and type of vessel adapted for a particular set of conditions, when all together would discuss the results of previous experience with other vessels built for the same duty, or any novel considerations arising from the general nature of the work to be performed. In the merchant service, it will be found that, as a rule, the larger vessels are used only for long voyages, and that, for comparatively short distances, smaller vessels making more frequent trips are preferred. Practice in this respect is sufficiently universal to be called a law, as differences of size will be noticed even between the ferry boats crossing the East and North Rivers at New York, those running the longer distances on the North River side being much the larger, and it will even be found that the larger boats of the Union Ferry Co. are selected to make the longer trips to South and Hamilton Avenue ferries, also that on the long Williamsburg and Hunter's Point ferries the boats are larger than on short ferries like those running from Fulton and Wall Streets. In vessels for the U. S. navy, the question of size is settled by the offensive power or speed it is proposed at the time to provide for. The two qualifications are separated for the reason that if a comparatively heavy armament be proposed for a vessel of a given size, the displacement to carry it must be obtained by sacrificing the weight of machinery. Similarly, high speed may be obtained by sacrificing the weight of armament; and if both high speed and a heavy armament are required together, the size of the vessel must be increased. In addition, both space and displacement must be provided for the coal, ordnance, and other stores, and proper accommodations for the officers and crew. In a merchant steamer, the machinery, fuel, and cargo, and accommodations and modern appliances for the convenience of passengers must be provided for. The final result can only be obtained by a series of trials, alterations, and compromises of one department with another, until a vessel is produced which, as a whole, is a compromise, and rarely in any one feature equal to all that the party representing that particular feature desires.

In the preparation of plans, the naval architect and engineer must in a sense work together, and can better do so under one direction, in distributing to the various departments the space available and the proper proportion of the displacement. In this connection it will be necessary for the engineer to prepare at least sketches, or, better, small-sized scale drawings of the machinery it is proposed to use as it is developed upon the basis of considerations hereinafter to be enumerated, and to furnish the weights of its various items concentrated at the centers of gravity of the several masses, so that not only the proper proportion of the displacement may be reserved to carry the total weight of the machinery, but the several details be so located that when balanced with the constructive weights of the hull and the added weights of equipment, cargo, etc., the hull will have the right draught and trim. The preparation of these preliminary plans, and of the specifications afterward, will necessarily settle all the details of construction. The several questions will be naturally considered in the following order: 1st. The power required for a hull of given size and draught of water to produce the desired speed. 2d. The type of machinery to be employed. 3d. The general dimensions and design of the boiler required. 4th. The general dimensions and design of the engine and of its principal details. 5th. The preliminary calculation of weights, previously referred to. 6th. The preparation of the specifications for the work complete. And, 7th, the contract for the work, the superintendence of its construction, the dock and sea trials, and the transfer of the completed vessel from the contractor to the owner. The power required to propel a given hull at a given speed depends so much upon the shape of the hull below the water line that it seems unfortunate in some cases that the engineers are not the ones to fix the lines of the hull and adapt them to the conditions. The most successful vessels are now designed by those who, though naval architects, are by education and experience engineers in the broadest sense of the term, and can therefore consider the questions of the proper shape of the vessel and the various compromises which must enter into the details of its construction as parts of one problem. The object to be attained in designing the lines of a vessel is to pass from the front to the rear a column of water equal in cross area to that of the midship section of the vessel with a velocity equal to the speed of the vessel. If the vessel were cigar shaped and submerged in a tube of double the area of its midship section, necessarily the water around it would be required to run backward at the same velocity with respect to the tube as the vessel went ahead, and with double that velocity with respect to the hull. If there were no friction, this transfer of water from the front to the rear could be made with very little loss of power, for the reason that the pressure required to produce the velocity in front would be advantageously given up to the rear of a vessel of proper shape, by reaction, as in the operation of turbines. In practice the backward current is less confined and consequently some power is lost, even below the surface, in moving water which cannot return its energy to the hull. In addition to this, when a vessel floats on the surface some water must be thrown off in waves from which only a small portion of the energy stored up can be imparted to the stern, and the remainder is dissipated in smaller waves of ever-increasing area in all directions.

The chief problem is therefore to reduce the formation of waves to a minimum, and to produce those that are necessary where they will do the least injury. This can best be accomplished by so forming the vessel that the water will, as far as possible, be thrown underneath or around the sides, well below the water line. It has been urged that the water should be opened with a bow containing concave or, as they are called, "hollow" lines, so that the velocity of separation will increase gradually to the middle of the forebody, where the curvature should reverse and the opening of the water thereafter be more gradual. It should be borne in mind, however, that a hollow line entrance necessarily makes the angle more obtuse, and vessel more blunt at or near the first half of the forebody, than if the entrance at the bow were less sharp, in which case the slope will be more nearly uniform and the maximum angle less. A straight line on the bow, or even one that is convex, rather than concave, may lift more water directly at the bow, but the superior elevation of the water at that point will force it under the vessel. The hollow line vessels generally show that there is a regular shoulder under water, by the fact that a high wave is forced out near the middle of the forebody, which slopes aft on account of the speed of the ship, from which wave only a part of the energy can be returned to the hull. A very little consideration will show that the nearer the first wave is brought to the bow, the less energy will be dissipated. It has, therefore, for a long time been the opinion of the speaker that many vessels are made too sharp at the bow on the water line, and, in the endeavor to get a straight stem, too blunt below the water line. The vessel should not, however, be cut away too much down at the keel forward, for the displacement which can be secured by carrying forward the floor is very efficient in preventing the vessel from pitching in a seaway, and does not produce injurious resistance, for the reason that at that point there is very little water to displace, as the main part of the hull is above it. A long easy "run" or afterbody, with hollow lines near the stern, is desirable, as it permits the water which has been elevated by the motion of the ship to fall back under the stern readily and give up its energy on the inclined surfaces to assist in propelling the vessel, and moreover gives an ample supply of water to the screw propeller, thereby securing, as a whole, higher efficiency and greater speed. It is also thought that the beam of a sea-going vessel will be increased very greatly compared to what it has been in the past, with a view of forcing the water under rather than around the sides of the hull. This subject is not without its difficult features, as such a vessel may be too "stiff" or endeavor to right herself too quickly in a seaway, and thereby be very uncomfortable. This principle was carried to an extreme in the construction of a yacht for the Czar of Russia, which was nearly circular, and was found so uncomfortable that she was turned into a troop ship. Undoubtedly the highest speeds of the future will be obtained with the hulls which are swelled out below the water line so that the water will be displaced, where it will form less waves, while the initial stability can be controlled by the distribution of the weight and a reduced area at the water line. The cutter shape so much in vogue in England, viz., a narrow deep hull, can in sailing vessels be made very safe, and such vessels generally cut through rather than ride over the waves. The safety is, however, due to the fact that heavy masses of lead are attached to the keel, carrying the center of gravity very much below the center of displacement; but when this general form of vessel is used in the construction of men-of-war, where the weights are necessarily high, the center of gravity and center of displacement so nearly approach each other that the metacentric height becomes very low when the vessel is "heeled," and by carelessness in computing the position of the center of gravity (rather than of displacement probably), occasions have arisen where the vessels were not safe, and some have actually tipped over and been lost for the want of sufficient stability. With small vessels it is found that while those with hollow lines forward may do well in still water, they pitch violently at sea and lose headway by burying in the waves. The form of vessel, therefore, which is somewhat full below water does not bury as much and is easier at sea, but for reasons before expressed, the fullness should be kept well down near the keel rather than at the horizontal water lines near mid-draught. It has been demonstrated in the speaker's experience that a small yacht with rather full water lines at the surface of the water, but hollowed out below, required less power than a Herreschoff yacht of the same length, when driven at the same speed, though the latter was considerably sharper on the water line and had considerably less displacement. It can readily be seen by watching one of these horizontal wedges, as the narrow yachts may be termed, that they cause a depression amidship, which might as well be filled by additional hull as by vacancy, without perceptible increase of resistance. A compromise possessing the advantages of the two forms, for duty at sea, would seem to be a ram-shaped bow, blunt at the water line and sharper both above and below. The question is a broad one, which needs to be studied in detail with great care. Beginners should not think of attempting any new forms until they have had long experience with the old ones.

The engineer, having done all that is possible to secure a proper shape for the hull under the known conditions, is prepared to calculate the power required to propel the vessel at a given speed. It should be in general borne in mind that the resistance varies nearly as the square of the velocity, and hence that the power varies nearly as the cube of the velocity; so the simplest formula for determining the speed of the steamer is simply that the indicated horse power (I. H. P.) equals the cube of the speed multiplied by the midship section and divided by a constant which varies from 300 for small blunt vessels to 600 and upward for vessels of better form and greater length.

The United States revenue cutters which are required to do duty along the coast after storms in assisting vessels in distress are good examples of steamers made as small as they can be, and yet be able to take care of themselves and others. They must necessarily, therefore, have the power at least of the largest tug boats, and at the same time have hulls of sufficient size to accommodate the officers and crew, and to carry sufficient coal for ordinary voyages. These vessels vary from 125 to 160 feet in length, the average size having a length of about 140 feet, and a midship section of about 133⅓ square feet. The constant in the formula above stated for the average vessel is about 500 to 525, as found by trial. For vessels 160 feet long, the constant rises to 600, and for those 125 feet long, which have to carry as large a crew, and nearly as much coal, and, therefore, have much blunter lines, the constant drops to 450, and even 400 in some cases. We thus see the necessity of using judgment in the selection of the constant, and many efforts have been made to devise a formula which would take into consideration the shape of the hull without exercising so much judgment. The best formula for this purpose is that of Prof. Rankin, who deduced from a large number of trials of vessels of different sizes that the principal resistance of vessels of good form at fairly high speeds is due to skin resistance, and to provide for difference in model he constructed a formula based on the skin resistance, in which the actual immersed surface of the vessel is "augmented" by introducing a function of the mean angle of entrance into the formula, so that the probable speed of the vessel with such angle is determined from the skin resistance of an imaginary vessel of sufficiently greater surface dimensions to show that speed in a calculation based on the skin resistance. The formula was so carefully constructed that it has given the most accurate results of any other which has been proposed.

The speaker has attempted to obtain from Froude's formula of comparison the approximate speed of large

vessels compared with small ones. The Froude experiments were made by pulling models through a still tank of water, measuring the strain with a dynamometer, and carefully noting the speed. The models were carefully shaped to the form proposed for the large vessel, and the model and vessel compared at what were called "corresponding speeds," varying as the square roots of their respective lengths, at which speeds it was assumed that the resistances varied approximately as the cubes of the lengths.

From this we may deduce that, at the so-called corresponding speeds, the relative horse powers required would be as the three and one-half powers of the lengths. The effective power must necessarily be increased by dividing the calculated power by the coefficient of efficiency of the machinery and propeller as actually applied in the hull. On this basis, if we consider as a model a steam yacht designed by the writer, which was 118 ft. long, and made a speed of 12·88 knots an hour, with an average of 250 I. H. P., the corresponding speed of a steamer 4½ times the length, or say 531 feet long, would be the square root of 4·5, equals 2·12 times as great, or 27·3 knots. The yacht should be long enough to make the correction for increased unit resistance due to reduced length unnecessary, so on the basis that the power varies as the 7-2 power of the length, the large vessel at a speed of 27·3 knots should require 48,326 I. H. P. This speed is too high for comparison with ocean steamers now in operation, but the probable results for a reduced speed may be made on the customary basis that the I. H. P. is proportioned to the cube of the speed. This comparison gives 21,996 I. H. P. for a speed of 21 knots, which is known to be somewhat larger than the power actually required by steamers of this length at that speed. This may be accounted for from the fact that the yacht was not as good a model as that of the larger vessel and, therefore, showed a higher resistance, but since both are fair models, this should not make a great difference. If, however, we consider that the effective horse power of the large vessel was 63 per cent. of the I. H. P. and for the smaller one only 53 per cent., the power for the larger vessel would be reduced to 18,854 I. H. P., which is about right. This result shows that possibly Froude's method of comparison may be advantageously employed in ascertaining the speed of steamers of unusual size, by using other vessels of known performance as models. The Froude formulæ, however, need careful revision, as some of the preliminary assumptions were modified by the experimental results, and the accuracy of the results is simply due to the balancing of errors. All the formulæ adopted for this purpose under consideration are necessarily largely empirical and are not applicable through a very wide range. Even Rankin's formula gives speeds too low for our very large ocean steamers, which now cross the ocean at such remarkable speeds. Ordinarily it is about as well to use a formula containing a constant based on the results obtained with a steamer approximately of the same size, thereby utilizing the latest developments. The applicability of the simple formula I. H. P. equals speed cubed multiplied by the midship section, and divided by a constant, is shown by the fact that it will give for an ocean steamer about 500 feet long with a midship section of say 1,300 square feet, using as a constant 600, a speed of 21 knots with 18,522 horse power, and will give for a revenue cutter of 133⅓ square feet midship section, using same constant, a speed of 11 knots with 206 horse power—results in both cases substantially correct.

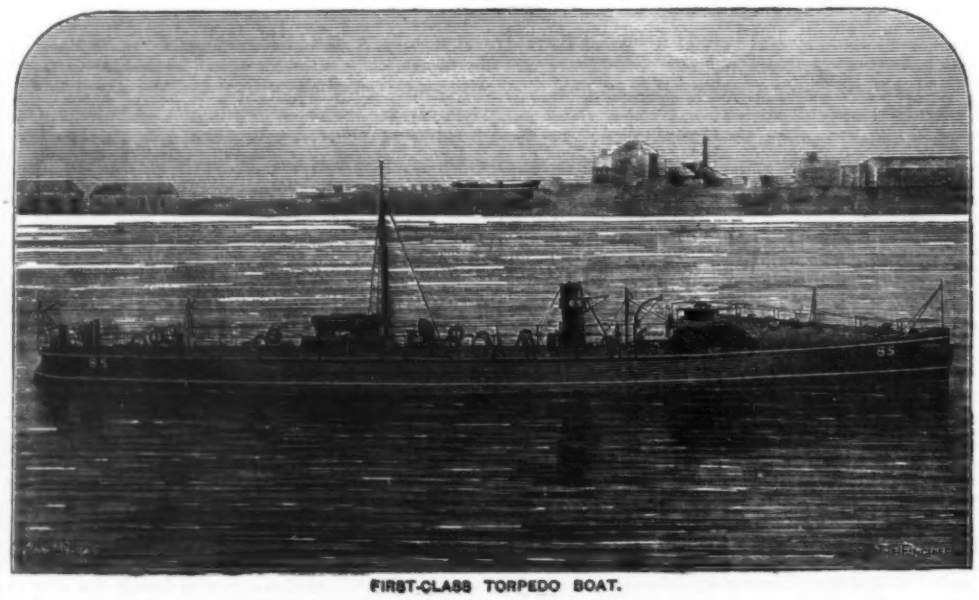
There is an interesting relation between the speeds of similar vessels of different size which are actually obtained in practice. The whole question in relation to steam yachts was very actively discussed several years ago in connection with the development of a time allowance for the regattas of the American Yacht Club. One gentleman, with great care, obtained the recorded speeds of yachts of different lengths on the water line and made up a table based thereon, suggesting that a yacht of a given length should make those speeds, but no rule was given by which the speeds for any other lengths than those stated could be computed. Others proposed time allowances in which it was attempted in various ways to consider the actual powers employed as well as the size of the vessel, so as to require the vessels containing the greatest power to make more speed in order to compare with others. The writer considered that as every vessel was a compromise, the fastest yacht of a given length, which provided suitable accommodations in addition to the required space and displacement for the machinery, was the better one; that is, that the owner had made the best use he could of the general dimensions he had selected, and that yachts of different sizes should only be handicapped by the increased dimensions the owner had selected. He, therefore, decided to adopt in a formula such function of the length of a yacht as would give fairly the speed customarily made by a first class yacht of that length, and from that compare the relative performances of other yachts of the same length, when the formula would make due allowance for the differences in length. This plan was received with favor, and several prizes termed "Emery Cups" have been awarded under what was termed the time allowance of the speaker, based on the rule that "the speed of the yacht in knots per hour should equal 2·7 times the cube root of the length of the hull on the water line."

Tables were prepared, of which an abstract is presented on the screen, giving the speeds of yachts of different lengths and the time required to run over the official course of 80 knots at such speeds, and the latter made the basis of the time allowance. For instance, a vessel which by rule should run 10 knots per hour was allowed eight hours, and one which by rule should run 16 knots an hour was allowed five hours, and the relative standings of vessels of all lengths were shown by the number of minutes each fell short or exceeded the time allowance due to its particular length. The rule proved to be remarkably well adapted for the vessels of the squadron. During the second regatta, the large yacht Atalanta, 229 feet long, belonging to Mr. Jay Gould, ran over the course within three minutes nine seconds of her time allowance on this basis; the Radha, 135 ft. long, within three seconds; the Rival, 88 ft. long, within three minutes fourteen seconds; other yachts within ten to twelve minutes, and no vessel was an hour behind its time allowance. Similar results were obtained at other regattas. This gratifying result does not show any theoretical relation between speed and length. It simply means that in ordinary practice the compromises of weight are so made that the rule expresses very closely the speeds that may be expected. When more power is applied and everything else sacrificed, higher speeds are obtained. It will be observed, also, that the rate of increase for length is less than that for comparison by Froude's formula, which shows simply that in yachts it is not ordinarily convenient to increase the horse power as the 7-2 power of the length, and, in fact, not quite as rapidly as the increase in cubic capacity; the increase in horse power being nearer the 7-3 power than the cube of the length.

TABLE OF TIME ALLOWANCES FOR STEAM YACHTS OF THE AMERICAN YACHT CLUB, BASED ON THE RULE SUBMITTED BY CHAS. R. EMERY, PH.D., THAT THE SPEED OF A YACHT IN KNOTS PER HOUR SHOULD EQUAL TWO AND SEVEN-TENTHS TIMES THE CUBE ROOT OF THE LENGTH OF THE YACHT IN FEET ON THE LOAD WATER LINE.

Length in Feet at Load Water Line.	Speed in Knots per Hour.	Time Allowed to Run 80 Knots.			
		Hours.	H.	M.	S.
50	9.947	8.0424	8	02	33
60	10.571	7.5673	7	33	42
70	11.127	7.1896	7	10	57
80	11.634	6.8760	6	51	49
90	12.099	6.6120	6	36	43
100	12.533	6.3833	6	23	01
110	12.936	6.1840	6	11	02
120	13.316	6.000	6	00	25
130	13.678	5.8488	5	50	55
140	14.018	5.7072	5	42	15
150	14.345	5.5768	5	34	36
160	14.658	5.4576	5	27	27
170	14.958	5.3480	5	20	53
180	15.244	5.2480	5	14	53
190	15.522	5.1538	5	09	14
200	15.790	5.0664	5	03	59
210	16.049	4.9848	4	59	05
220	16.300	4.9080	4	54	29
230	16.543	4.8360	4	50	10
240	16.778	4.7680	4	46	05
250	17.010	4.7032	4	42	12
260	17.234	4.6424	4	38	33
270	17.450	4.5848	4	35	05
280	17.663	4.5296	4	31	47
290	17.871	4.4768	4	28	36
300	18.074	4.4264	4	25	35

Having determined the probable power required by means of the above simple formula based on the midship section, checked by Rankin's formula, and any other that may be convenient, using, however, for comparison in all cases vessels as nearly the size proposed as possible, we next proceed to settle the type of machinery which is to be selected for producing the power in a hull of the size and form fixed by the other considerations hereinbefore referred to. It by no means follows that because triple compound engines are more economical in fuel that they are the best to use in every case, or would prove the most economical when all the conditions of the problem were taken into consideration. Where fuel is cheap or labor is dear, particularly where both conditions obtain at the same time, the simplest type of machinery is not only the best, but the cheapest in the long run, as the interest on the higher priced machinery must be considered. In light boats on the Western rivers, machinery involving even a trifle more weight, either in the engines themselves or any adjunct thereof, is not allowable. Many of the old river captains even think they can afford to pay as high as $30 for each pound of weight saved, which expresses a principle, even if extravagantly stated. In some of these rivers the vessel, as a whole, is liable to destruction, so cheapness as well as lightness is secured as much as possible. The same principles apply on the seaboard. A coaster cannot afford to save even $2 a day on fuel and pay out the same, or a greater quantity, for the wages of more experienced employes, or for the repairs to a more expensive type of machinery. Again, the interest account frequently makes it unadvisable to increase the expense of machinery, either in the merchant or government services, for the reason that the vessels lie idle to load in the one case, and wait very much of the time for emergencies or periods of duty to arrive in the other. A small government vessel running on the average three, or even as much as eight or ten hours a day, and lying under banked fires for the rest of the time, will waste the same fuel in keeping the fires alive, whether the engines be of high economy or low, and this consideration, together with interest on first cost, extra attention, and repairs, rapidly balances the gains, which affect simply the saving of fuel. Coasting vessels making cruises of two or three days' duration, and lying idle for the same time, can afford greater original expense, but not to a serious extent, as the economical management of such vessels requires that the number of the crew be kept down to the lowest possible limit, requiring hard work at sea but giving more liberty when in port. What may be called commercial considerations are really the governing ones in the selection of the type of machinery, and cannot permanently be ignored merely to secure economy in any one of the many directions in which money is expended in marine construction. In vessels crossing the sea, where the quantity of coal consumed is such an important proportion of the carrying capacity of the ship, and the cost of fuel, moreover, has an important bearing on the balance sheet, showing the profits of the voyage, it is necessary to select machinery of the highest economical type consistent with positive certainty and continuity of action. The considerations leading to a decision of the question as to the proper type of machinery, are: 1st. The kind of machinery which has proved serviceable already in that particular service. 2d. The success of innovations that are made in every service, and the causes of failure And. 3d, the success of different types in different parts of the country, or different parts of the world, where the duty is very much like that which is being studied. On these premises, it may be judged exactly what innovations will probably be successful, and the adaptations made on that basis. The question whether side wheels or screw propellers should be employed sometimes occurs, but not so frequently as in former years. The propeller engines with their higher speed are so much more compact and weigh so little in comparison with side wheel machinery, that they are usually employed wherever it is practicable. The latest improvements permit the economical use of screw propellers, even with vessels drawing as little as two feet of water,



FIRST-CLASS TORPEDO BOAT.

but their use is exceptional, as the light draught steamers with small feathering paddle wheels, used abroad, are very well adapted for the work and can be built in this country for such duty with advantage. There are, however, cases where screw propellers are entirely feasible that side wheels are used simply to obtain steadiness. The vessels crossing the English Channel are well known examples of this class. The channel passage, uncomfortable enough even on the present large side wheel steamers, would be doubly so if propellers were used, as they would naturally roll in those peculiarly stormy waters to a very uncomfortable extent. In designing the machinery for the U. S. revenue steamers, the writer at first put in quite a number of compound engines; then finding, in making the experiments, now so well known, with the Rush, Dexter, Dallas, and Gallatin, that very nearly the same results could be obtained with single engines using high steam pressures, by keeping the cylinders smaller than customary, so as not to attempt to get too much expansion, this type of engine was used for further construction for a time. When Congress became more liberal and made larger appropriations, it became desirable to obtain increased speed for the steamers. So compound engines were again resorted to to obtain more power, and were run at higher speeds than formerly, particularly when connected to twin screws.

The weight has an important bearing on the selection of machinery for a vessel. It will be readily understood that a certain power can be obtained with a certain steam pressure and certain degree of expansion, with a certain fixed piston development. This development may be obtained with a large engine running slowly, and the same may have a large piston and short stroke, or small piston and long stroke, or cylinders of smaller capacity can be used, and the engine required to make more revolutions. The high horse power secured in torpedo boats is obtained with small engines running at high speeds of revolution. For instance, a compound engine with a large cylinder 21 inches in diameter, with only 12 inches stroke, has been run regularly 438 revolutions per minute and furnished 460 I. H. P. The ordinary type of engine for 460 horse power in the merchant service would have a cylinder 36 to 42 inches in diameter and about 42 inches stroke, and be run at a speed of 65 to 80 per minute,

RELATIVE WEIGHTS OF STEAM MACHINERY OF DIFFERENT TYPES.

	Date.	Type.				Number of Engins.	Diam. of Cylinders.		Stroke of Pistons.	Steam Pressure.	Mean Pres. referred to large Cyl.	Rev. per Minute.	I. H. P.	Weight per I. H. P.				I. H. P. per Ton of Weight.
		Engine.	Boiler.	Propeller.	Condenser.		Small.	Large.						Engines.	Propellers and Shafting.	Boilers and Water.	Total.	
							Inches.	Inches.	Ft. In.	Lbs.	Lbs.			Lbs.	Lbs.	Lbs.	Lbs.	
British Naval Steamers.	1832	Side Lever	Flue	Paddle	Jet	2		55½	5 0	4	15·6	17·5	400				1,550	1·45
	1845	Vertical	Tubular	"	"	4		72	8 0	9	16·0	15·0	1,905	272	136	306	714	3·14
	1850	Oscillating	"	"	"	2		72	7 0	14	18·3	20·5	1,300	164	70	240	474	4·73
	1857	Trunk	"	Screw	"	2		82	4 0	20	21·8	54·0	3,005	106	45	254	405	5·53
	1870	Horizontal	"	"	Surface	4		72	3 0	30	24·5	73·9	5,384	127	30	140	297	7·50
	1876	Vert. Com.	"	"	"	2	70	114	3 10	60	20·9	78·8	7,696	124	38	193	350	6·40
	1882	Hor. "	Locom'tive	"	"	2	38	64	3 3	120	36·2	120·0	5,500	75	18	85	178	12·56
	1880	Vert. "	"	"	"	1	12¾	20⅝	1 0	120	50·2	438·0	460	20·7	3·65	35·3	59·65	37·66
U. S. Steamers.	Charleston 1889	Inclined C'mpound	Locom'tive Cylindrical	Twin Screw	"	2	44	85	3 0	90	27·4	116·3	6,943	236·2		107·4	343·6	6·52
	Baltimore 1889	Triple C'mpound	Cylindrical Tubular	"	"	2	42 60	94	3 6	135	26·2	120·6	9,549	231·4		115·1	346 5	6·43

according to the steam pressure and actual sizes employed. The weight of the engine last named would be about seven times as great as that of the first. The question arises at once, why not use torpedo boat practice in all cases? Simply for the reason that it is not desirable to strain up to the highest working point continuously any form of mechanism, any more than our own physical and mental faculties. The torpedo boat practice represents all that it is possible to get out of a given mass of material. At such high speeds, the least neglect of the oiler will cause the brasses and bearings to be cut, and very slight mishaps culminate in permanent injury to the machinery, requiring its disuse until repairs can be made. Such work is a necessity in torpedo practice, but the difficulty of obtaining in regular practice the results which the contractor is obliged to guarantee, is shown by the fact that so many torpedo boats break down during seasons of practice when handled by such naval crews as can be obtained for the purpose.

There is exhibited here a photograph of one of these vessels, built by Yarrow, which has run for three hours at an average speed of 22½ knots per hour, but to secure such speed the vessel was practically built of sheet iron, riveted together cold, and the weight of all parts cut down to a minimum. The general strength of the structure can be best understood by explaining that this particular vessel, in making a landing with the writer and others on board, touched the dock very lightly, but, as it proved, with sufficient force to crash in the side of the vessel, showing conclusively that such a vessel would not be fit for a boarding cutter, which has to run up to a moving steamer at full speed. These facts should be fully understood by those who compare the government vessels, which have to do this rough duty, with the mere shells which have nothing to do but rush up with projectiles and get away as best they can. Evidently in ordinary practice a different type of machinery must be employed, though the introduction of the torpedo boat system has had the effect to modify modern construction so as to obtain some of the advantages of high speed and reduced weight.

In this connection we present as a matter of interest a table extracted principally from a paper of Chief Engineer Sennett, of the English navy, illustrating from the vessels of that navy the effect of the various improvements in the machinery of steamers since the advent of steam navigation. In 1832, with side lever paddle wheel engines, flue boilers carrying only four lb. of steam, and jet condensers, there was only 1·45 I. H. P. obtained per ton of weight. Tubular boilers and 9 lb. pressure increased the power to 3 14 I. H. P. per ton in 1845; oscillating engines and 14 lb. of steam to 4·72 I. H. P. per ton in 1850; screw engines and 20 lb. of steam to 5·52 I. H. P. in 1857; and the surface condenser and 30 lb. of steam to 7·5 I. H. P per ton in 1870. The compound engine with 60 lb. of steam only obtained 6·4 I. H. P. per ton in 1876, but, of course, greatly reduced the total weight carried on account of reduced coal consumption. Triple compound engines, on the whole, only produce a saving in fuel, rather than of weight, to be carried. The increase of weight due to compound and triple compound engines is chiefly caused by the heavier boilers required for the higher pressures, though the engines are generally somewhat heavier. The introduction of forced blast has, however, enabled the weight of the boiler to be reduced, and high speeds, as previously referred to, reduces the weight of the engine so, as shown, the torpedo boat machinery developed in 1880 gave 37·66 I. H. P. per ton of weight, and in a fast steamer built in 1882, as a compromise between the ordinary and torpedo boat types of machinery, 12·56 I. H. P. was obtained per ton of weight. Steam pinnaces are now in regular use in the British navy with machinery patterned after that of the torpedo boats, which furnish 22·2 I. H. P. per ton of weight. Boats of superior speed of this class were first built in this country by Herreschoff, of Bristol, R. I.

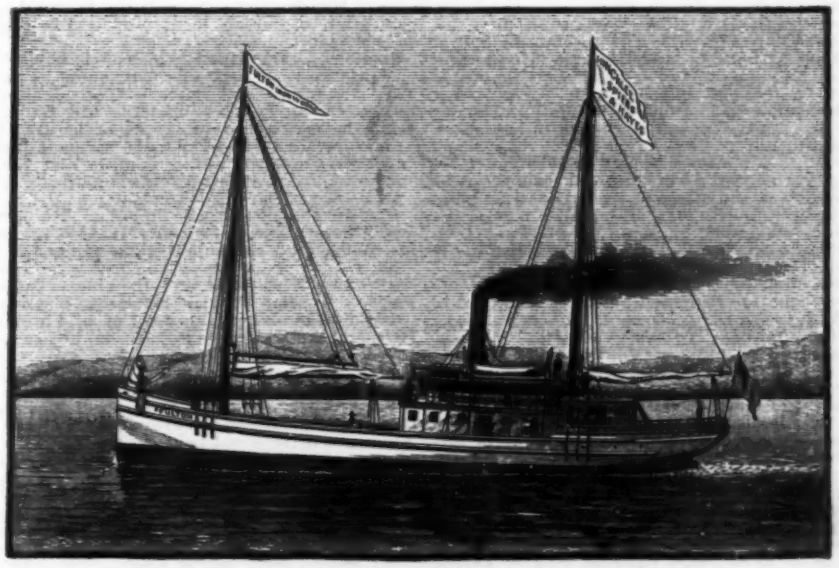
It is interesting in the table to observe the progressive increase of steam pressure, of revolutions, of the I. H. P., and to some extent of the mean pressure per ton of weight, in connection with the decrease in the several items of weight.

The economy of triple compound engines compared with that of compound engines of best construction has not until recently been satisfactorily determined. It has been shown that vessels with triple compound machinery ran more economically than the old compound engines, but the published comparisons were made with the latter when run down after years of constant use. In a paper by the writer on "The Development of the Compound Engine," etc., Trans. Am. Soc. M. E., vol. viii., the writer deduced from actual experiments with the compound engine of the Rush that if the pressure were doubled, so that two more expansions were secured in another cylinder, the power should be obtained for 15·15 lb. of feed water per I. H. P. per hour, and this is practically the result shown, we are informed, by recent experiments, the report of which has not yet been examined. Leaving the special consideration of the weights in detail till the subject comes up in the order first named, we will proceed to the general considerations necessary in fixing the type of boiler, and then discuss the manner of determining its general dimensions for a particular case. Boilers with flues or large tubes may be considered a thing of the past, except for use in very muddy water, with highly bituminous coal—a condition that exists on our Western rivers. The higher pressures now required reduce the number of what are called tubular boilers available down to a few general types. In the form most commonly used, known frequently as the Scotch type, tubes are arranged over circular furnaces in cylindrical shells, requiring but little bracing. The weight of water in these boilers is, however, large, so the ordinary locomotive type, with tubes arranged in a continuation of the furnaces, has generally been adopted for torpedo vessels.

(To be continued.)

PACIFIC COAST STEAM SCHOONERS.

AN engraving is herewith given which illustrates the type of steam schooner in use on this coast. Most of them are employed in running to and from the lumber ports, and in carrying produce of different kinds.



PACIFIC COAST STEAM SCHOONER

They make their trips regularly, and with sufficient speed for freight purposes.—*Mining and Scientific Press.*

[Continued from SUPPLEMENT, No. 782, p. 11691.]

THE NICARAGUA CANAL—ACROSS NICARAGUA WITH TRANSIT AND MACHETE.*

By R. E. PEARY.

THE special phase of field work which fell to my personal lot was entirely reconnoissance, consisting of canoe examinations of all streams in the vicinity of the line of the canal, to determine their sources, character of valley, and approximate watershed; of rapid air-line compass and aneroid trails, to connect one stream or valley head with another, or furnish a base line for a general sketch plan of a valley; and of studies of the larger features of the terrene, from elevated tree tops.

The last has been already described; in the second the experience was very similar to that of the parties in running main lines. On these occasions three or at most four hardy *huleros* (rubber hunters) comprised the party, two carrying the blankets, mosquito bars, and provisions for several days, and one or two cutting the lightest possible practicable trail and marking prominent trees.

In a day's march of from five to eight miles (and this was the utmost that even such a light, active, and experienced party could cover in one day), every possible and some almost impossible kinds of traveling was encountered, and thoroughly exhausted men crept into their bars every night.

The canoe reconnoissances were more agreeable, though some most unpleasant as well as most enjoyable memories are connected with them.

The innumerable large fallen trees which obstruct the streams and over or through which the canoe must be hauled bodily, the almost inevitable capsizing of the canoe, the monotonous red clay banks on either side, and the frequent necessity of lying down at night in a bed of mud into which the droves of wild pigs which inhabit these valleys have trampled the clayey soil, are among the disagreeable incidents.

From the head of canoe navigation to their sources the character of these streams is entirely different, and both in 1888 and in 1885 I have followed them far up into mountain gorges, the beauty of which is as fresh in my memory as if I had been there but yesterday.

The crew of the canoe on these reconnoissances usually consisted of three picked men, and when the canoe had been pushed as far up stream as it was possible for it to go, two of the men were left with it, while the third and best, slinging the blankets, bars, and a little coffee, sugar, and milk upon his back, pushed on with me. Wading through the shallow water up the bed of the stream, taking bearings and estimating distances, while my *huleró* followed, ever alert to strike some drowsy beauty of a fish in the clear water the source of the stream was generally reached in a day, and never did we make preparations to sleep on some bed of clean, yellow sand washed down by the stream in flood times, but what I had a plump turkey hanging from my belt, and my *huleró* several fine fish.

Much has been written about the climate of Nicaragua and its effect upon the inhabitants of more northerly countries when exposed to it.

It would seem that the experience of the numerous expeditions sent out by the United States, and the reports of the surgeons attached to those expeditions, would have long since settled the matter. To those who cannot understand how there can be such a difference in climate between two localities so slightly removed as Panama and Nicaragua, and the former possessing a notoriously deadly climate, the experience of the recent surveying expedition must be conclusive.

Only five members of that expedition had ever been in tropical climates before, and the rodmen and chainmen of the party were young men just out of college who had never done a day's manual labor, nor slept on the ground a night in their lives. Arriving at Greytown during the rainy season, the first work that they encountered was the transporting of their supplies and camp equipage to the sites of the various camps. This had to be done by means of canoes along streams obstructed with logs and fallen trees. Some parties were a week in reaching their destination, wading and swimming by day, lifting and pushing their canoes along, and at night lying down on the ground to sleep.

One party worked for six months in the swamps and lagoon region directly back of Greytown, and several other parties worked for an equal length of time in the equally disagreeable swamps of the valley of the San

* An address delivered before the National Geographic Society, Washington. From the National Geographic Magazine.

Francisco. Several of these officers are down there yet, as fresh as ever. In making tours of inspection of the different sections I have repeatedly, for several days and nights in succession, passed the days traveling in the woods through swamps and rain, and the nights sleeping as best I could, curled up under a blanket in a small canoe, while my men paddled from one camp to the next.

In spite of all this exposure, not only were there no deaths in the expedition, but there was not a single case of serious illness, and the officers who have returned up to this time were in better health and weight than when they went away.

Of course the men had the best of food that money could obtain and previous experience suggest, and the chiefs of all parties were required to strictly enforce certain sanitary regulations in regard to coffee in the morning, a thorough bath and dose of spirits on returning from work, and mosquito bars and dry sleeping suits at night; yet the climate must be held principally responsible for a sanitary result which I believe could not be excelled in any temperate zone city, with the same number of men doing the same arduous work under conditions of equal exposure.

The forests everywhere abound in game, and every party which included in its *personnel* a good rifle shot was sure of a constant supply of wild pig, turkey, quail, and grouse, varied by an occasional deer, all obtained in the ordinary work of reconnoissance and surveying. For the men's table there was abundance of monkey, iguana, and macaw.

Parties in the lower valleys of the various streams had no trouble in adding two or three varieties of very toothsome fish to their bill of fare, though these fish were rarely caught with the hook, but usually shot, or knifed by an alert native, as they basked in the shallows. These parties also obtained occasionally a *danta* (tapir) or a manatee.

On the river it was possible to obtain a fine string of fish with hook and line. Then there was the huge tarpon to be had for the spearing, and fish pots sunk in suitable places were sure to yield a mess of fresh water lobsters. Ducks were also occasionally shot.

The forms of life are even more numerous in the vegetable than in the animal kingdom. The effect of these wonderful forests is indescribable, and though many writers have essayed a description, I have yet to see one that does the subject justice. Only a simple enumeration of component parts will be attempted here. First comes the grand body of the forest, huge almendro, havilan, guachipilin, cortez, cedar, cotton-wood, palo de leche trees and others rising one hundred and fifty or two hundred feet into the scintillant sunshine. The entire foliage of these trees is at the top, and their great trunks reaching up for a hundred feet or more without a branch offer a wonderful variety of studies in types of column. Some rise straight and smooth and true, others send out thin, deep buttresses, and others look like the muscle-knotted forearm of a Titan, with gnarled fingers griping the ground in their wide grasp.

But whatever the form of the tree trunks may be, the shallow soil upon the hills and the marshy soil in the lowlands has taught them that there is greater safety and stability in broad foundation than in a deeply penetrating one, and so almost without exception the tree roots spread out widely, on or near the surface. Beneath the protecting shelter of these patriarchs, as completely protected from scorching sun and rushing wind as if in a conservatory, grow innumerable varieties of palms, young trees destined some day to be giants themselves, and others which never attain great size. Still lower down luxuriate smaller palms, tree ferns, and dense underbush and countless vines. These latter, however, are by no means confined to the underbush. Many of them climb to the very tops of the tallest trees, cling about their trunks and bind them to other trees and to the ground with the toughest of ropes. With one or two exceptions, these vines are an unmitigated nuisance. To them more than to anything else is due the impenetrableness of the tropical thicket. Of all sizes and all as tough as hemp lines, they creep along the ground, catching the traveler's feet in a mesh from which release is possible only by cutting. They bind the underbush together in a tough, elastic mat, which catches and holds on to every projection about the clothes, jerking revolvers from belts, and wrenching the rifle from the hand, or, hanging in trap-like loops from the trees, catch one about the neck, of constantly drag one's hat from the head. The one exception noted above is the *bejuco de agua* or water vine. This vine, which looks like an old worn manila rope, is to be found hanging from or twined about every large tree upon elevated ground, and to the hot and thirsty explorer it furnishes a most deliciously cool and clear draught.

Seizing the vine in the left hand, a stroke of the *machête* severs it a foot or two below the hand, and another quick stroke severs it again above the hand; immediately a stream of clear, tasteless water issues from the lower end and may be caught in a dipper or, *à la native*, directly in the mouth. A three-foot length of vine two inches in diameter will furnish at least a pint of water. The order of cutting mentioned above must invariably be adhered to, otherwise, if the upper cut be made first, the thirsty novice will find he has in his hand only a piece of dry cork-like rope.

It is practically impossible to judge of the age of the huge trees in these forests. Mighty with inherent strength, stayed to the ground and to their fellows by the numerous vines, sheltered and protected also by their fellows from the shock of storms, their huge trunks have little to do except support the direct weight of the tops, and they rarely fall until they have reached the last stages of decay. Then some day the sudden impact of a ton or two of water dropped from some furious topical shower, or the vibrations from a hurrying troop of monkeys, or the spring of a tiger, is too much for one of the giant branches heavy with its load of vines and parasites, and it gives way, breaking the vines in every direction and splitting a huge strip from the main trunk. With its supports thus broken and the whole weight of the remaining branches on one side, the weakened trunk sways for a moment, then bows to its fate. The remaining vines break with the resistless strain, and the old giant, gathering velocity as he falls and dragging with him everything in his reach, crashes to the earth with a roar which elicits cries of terror from bird and beast, and goes booming through the quivering forest like the report of a heavy cannon. A patch of blue sky overhead and a pile of impenetrable debris below mark for years the grave of the old hero.

As regards the insect and reptile pests of the country, it has been my experience that both their numbers and capacity for torment have been greatly exaggerated. Mosquitoes, flies of various sizes, wasps and stinging ants exist, and the first in some places in large numbers; yet to a person who has any of the woodsman's craft of taking care of himself, and whose blood is not abnormally sensitive to insect poisons, they present no terrors and but slight annoyances. At our headquarters camp on San Francisco Island, we had no mosquitoes from sunrise to sunset, and even after sunset they were not especially numerous. At another camp only a few miles away there were black flies only, and no mosquitoes, at another both, while at the camps up the hills there were neither. It was only at camps in the wet lowlands and near swamps that they became an almost unendurable annoyance. Even here it was those who remained in camp that suffered most. Men out in the thick brush were but little annoyed by them, and when on their return to camp they had finished their dinner and gotten into their mosquito bars, they were out of their reach. As to snakes, the danger from them even to a European is practically nothing. Not a man of the several hundred that have been engaged in the various expeditions in that country has ever been bitten, and in hundreds of miles of tramping through the worst forests of the country, either entirely alone or accompanied by natives, with them some distance in the rear, I have never fancied myself in danger. The poisonous snakes are invariably sluggish, and unless actually struck or stepped upon are apt to try to get out of the way, if they make any move. The only snake that is at all aggressive, as far as my observations go, is a long, black, non-poisonous snake. This will sometimes advance upon the intruder with head raised a couple of feet from the ground, or if coiled about a tree will lash at him with its tail.

The floral exhibit of these forests is apt to be disappointing to one whose ideas have been formed by a perusal of books. An occasional scarlet passion flower; now and then the fragrant cluster of the *flor del toro;* a few insignificant though fragrant flowering shrubs; and in muddy sloughs near the streams, patches of wild callas, are about all that meet the eye of the non-botanical wanderer in the deep forest.

There is not light enough for flowers beneath the dense canopy of trees, and they, like the smaller birds, seek the tree tops and banks of the river, where sunlight and air are abundant. In the tree tops the orchids and other flowering parasites run riot. Many of the trees are themselves flowering, and if one can look down upon the tree tops of a valley in March or April, he sees the green expanse enlivened by blazing patches of crimson, yellow, purple, pink, and white.

The river banks are the favorite home of the flowering vines, and there they form great curtains swaying from the trees in bright patterns of yellow, pink, red, and white. The grassy banks and islands and the shallow sand spits also bring forth innumerable varieties of aquatic plants.

So much for the Atlantic slope of the country.

On the west side between the lake and the Pacific the work is very different. There it is possible to ride mule back to the top of a commanding hill, sit down, and make the reconnoissance sketch at leisure. The secondary reconnoissances may also be made mule back, and everywhere the rolling country and the cleared and cultivated fields permit the engineer to see where he is going and how he is going.

His surroundings are also different. He moves camp in an ox cart instead of canoe. His eyes, instead of being confined by the impenetrable veil of the tropical thicket, feast upon views of the distant mountains, the crisp waves of the lake, and the blue expanse of the Pacific. During the day he meets black-eyed and brown-limbed senoritas instead of wild hogs and turkeys, and at night, when he turns in, he hears, not the scream of tigers, but the songs of the *lavandera's* ecru daughters floating across the stream which supplies their wash-tubs and his camp.

The first grand natural feature which arrests attention in the most cursory examination of the map of Nicaragua is the Great Lake. This lake, with an area of some three thousand square miles and a watershed of about eight thousand square miles, is unique in the large proportion of its own area to that of its watershed. A result of this large proportion of water surface to drainage area, at once evident, is the very gradual changes of level of the lake and their confinement within very narrow limits. The difference between the level of the lake at the close of an abnormally dry season and its level at the close of an abnormally wet season is not more than ten feet, and the usual annual fluctuation is about five feet.

The next features that arrest attention are first the very narrow ribbon of land intervening between the western shore of the lake and the Pacific, and second the entire absence of lateral tributaries of any size to the upper half of the San Juan River. The river is in fact, as it was originally most aptly named, simply the "Desaguadero" or drain of the lake.

The length of this river is one hundred and twenty miles, from the lake to the Caribbean Sea, and its total fall from one hundred to one hundred and ten feet. Nature has separated the river into two nearly equal divisions, presenting distinct and opposite characteristics.

From Lake Nicaragua to the mouth of the Rio San Carlos, a distance of sixty-one miles, in which occur several rapids, the total descent is fifty feet, quite irregularly distributed, however. The surface slopes of the river vary from as much as 83·38 inches per mile for a short distance at Castillo rapids to only 0·90 inch per mile through the Agua Muerte, the dead water below the Machuca rapids.

The average width of the river through this upper section is seven hundred feet, the minimum four hundred and twenty. In some parts of the Agua Muerte the depth varies from fifty to seventy-five feet.

There are very few islands in this section of the river, the banks are covered with huge trees matted with vines, and throughout the lower half of the division, from Toro rapids to the mouth of the San Carlos, the river is confined between steep hills and mountains.

As a result of the absence of considerable tributaries already noted, the fluctuations of this portion of the river conform closely to those of the lake, and consequently take place gradually and are limited in range.

Below the Rio San Carlos the San Juan changes its character entirely. Its average width is twelve hundred and fifty feet, its bottom is sandy, there are numerous islands, and the slope of the river is almost uniformly one foot per mile.

The discharge into this section of two large tributaries, the San Carlos and the Sarapiqui, descending from the steep slopes of the Costa Rican volcanoes, causes much more sudden and considerable fluctuations of level than in the upper river.

While the lower portion of the river, and especially the Delta section, presents very interesting features, yet the peculiar charm of the river is in the upper section, and the exceptional advantages it offers for obtaining miles of slack water navigation. This portion of the river with the lake and the narrow isthmus between it and the Pacific forms a trio of natural advantages for the construction of a canal, the importance of which it would be difficult to overestimate.

About three miles below the mouth of the San Carlos, the Cano Machado enters the San Juan on the north bank. This stream, about one hundred feet wide and from eight to ten feet deep, is the last of the mountain or torrential tributaries of the San Juan. It can scarcely be said to have a valley, but occupies the bed of a rugged ravine extending for several miles northerly and northwesterly up into the easterly flank of the cordillera. Every variety of igneous rock, from light porous pumice to dense metallic green black hypersthene andesite, may be picked up in the bed of this stream. Agates also are common and there are occasional masses of jasper. Further up, frequent outcrops of trap *in situ* occur, interspersed in some localities with numerous veins of agate.

Twelve miles below the Machado the San Francisco enters the San Juan. This stream, with its several tributaries, drains a large swampy valley sprinkled with irregular hummocks and hills. For several miles from the San Juan it is a sluggish, muddy stream between steep slippery banks; higher up, flowing over a gravelly and then a rocky bed, it finally disappears in steep ravines filled with huge bowlders. The main San Francisco comes from the northwest, but a large tributary has its source to the eastward in a range of hills which separates the San Francisco basin from the immediate Caribbean watershed. This range, unlike the ones already noted, is at heart an uninterrupted mass of homogeneous hypersthene andesite, and with one exception nothing but fragments of trap or trap *in situ* is to be found in any of the streams descending from either its western or eastern slopes. The one exception is the Canito Maria, a tributary of the San Francisco, entering it but little more than a mile from the San Juan. In the bed of this stream were abundant specimens of agates, jasper, and petrified woods of several varieties in a wonderfully good state of preservation.

This range of hills ends at the Tamborcito bend of the San Juan, four miles below the mouth of the San Francisco, and is the last easterly projecting spur from the mountain backbone of the interior. Between it and the coast there are, however, mountain masses of equal or greater elevation, notably "El Gigante" and the Silico Hills, the former some fifteen hundred feet high, but these are simply isolated mountain ganglia, their innumerable radiating spurs speedily giving way to swamps or river valleys.

The streams that flow down the eastern slope of the Silico Hills are from their sources to the lowlands of almost idyllic beauty. Beginning as noisy little brooks tumbling over black rocks in a V-shaped ravine near the summit of the hills, they rapidly gather volume and slide along in a polished channel of trap, tumbling every now and then as sheets of white spray over vertical ledges; forming here and there deep green pools, and then, after they have passed down among the foot hills, rippling in broad shallow reaches over sunlit beds of bright yellow gravel. The water of these streams is clear and sparkling as that of an Alpine stream and apparently almost as cool. The insect pests of the tropics are unknown in the elevated portions of their valleys, and I have slept more than once beside one of these streams, several hundred feet above sea level, without a mosquito bar, while the delightful "trades," rustling through the trees above me, brought the murmur of the Caribbean surf miles away to mingle with that of the stream.

The soil of this range consists, to a depth of ten to forty feet, of clay of various grades and colors, red prevailing. In the valleys this clay is almost invariably of a very dense consistency and deep dark red in color.

From the foot hills of the range to the coast is a low, level stretch of country, a dozen miles wide, interspersed with lagoons and swamps. Near the hills, where the elevation of the ground will average about fifteen feet above sea level, the soil is composed almost entirely of the before mentioned red clay, which occasionally assumes the form of hummocks. Within about six miles of the coast this stratum of clay gradually disappears under a layer of sand, which is in turn covered by a vegetable mould to a depth of a few feet. From this point to the sea the average elevation is barely five feet above the sea level, and the sand and mould above mentioned are the only materials met. A short distance from the ocean the vegetable earth covering disappears and only the sand is left, extending to an unknown depth and reaching into the sea.

West of Lake Nicaragua, from the Rio Lajas to Brito, as we leave the lake shore, the ground rises almost imperceptibly to the "Divide" among cleared and gently undulating fields. Then we drop into the sinuous gorge of the Rio Grande, only to emerge, a few miles farther on, into the upper end of the Rio Grande and Tola basin.

To the right the Tola valley stretches to the northward, and all around high and wooded hills encircle the valleys except directly in front, where a narrow gateway in the coast hills opens to the Pacific. In the bottom of this valley are a few farms, and through it wander devious roads. Beyond the narrow gateway in the hills, less than three miles of level swampy *salinas* reach to the surf of the Pacific.

The views from the hills which flank the gateway of the Rio Grande, at La Flor, are wonderfully attractive. I well remember one camp on the hillside, from which in one direction the eye takes in the fertile valley of the Tola and Rio Grande, backed by the rolling hills of

the "Divide," and over them the symmetrical peak of Ometepe, its base washed by the waves of the great lake. In the other direction the Pacific lies apparently but a stone's throw below the little port of Brito at one's very feet.

This same camp inspired one young engineer and enthusiast to express himself something as follows:

"What if, in this camp, we should, like Rip Van Winkle, sleep for ten years, and then awakening look about us? We are still at Brito, but instead of being in the wilderness, we look down upon a thriving city. In the harbor are ships from all ports of the world. Ships from San Francisco, bound for New York, about to pass through the canal and shorten their journey by 10,000 miles. Ships from Valparaiso, headed for New York, will take the short cut and save 5,000 miles and the dread storms of Cape Horn. At many a masthead floats the British flag, and vessels from Liverpool, with their bows turned toward San Francisco, have shortened their journey by 7,000 miles.

"We go aboard one of the many steamers flying the 'stars and stripes' and start eastward. All along the line the face of the country has changed; the fertile shores of the Tola basin are occupied by cacao plantations, fields have replaced forests, villages have grown to towns, and factories driven by the exhaustless water power furnished by the canal have sprung up on every available site.

"Along the shore of the lake are immense dry docks, and vessels are resting in this huge fresh water harbor before setting out again on their long voyages. The broad bosom of the noble San Juan is quivering with the strokes of tireless propellers. The roar of the great dam at Ochoa is heard for a moment, and then the eastern section of the canal is entered. Here the country is scarcely recognizable, so greatly has it changed. Wilderness and marsh have disappeared, and only great fields of plantains and bananas and dark green orange groves are to be seen. A day from Brito, and the steamer's bow is rising to the long blue swell of the Caribbean at Greytown.

Well is this picture calculated to excite enthusiasm, for it means the dream of centuries realized, the cry of commerce answered, and our imperial Orient and Occident facing republic resting content with coasts united from Eastport to the Strait of Fuca.

[Continued from SUPPLEMENT, No. 732, p. 11693.]

LIME SULPHITE FIBER MANUFACTURE IN THE UNITED STATES.

By Major O. E. MICHAELIS, M. Am. Soc. C.E.

THE GRAHAM.

THE Graham digester, 7½ x 22 feet, is made of sheets of boiler plate, to which the lead lining is soldered before bending and assembling. The method of doing this is ingenious and simple.

The sheet is cleansed and smoothed by a radially traveling emery wheel; it is then firmly fixed for half its surface over a gas jet heater. The rectangular frame that holds it down is packed with fire-proof packing where it rests upon the plate, thus actually forming a water-tight vessel, of which the iron to be leaded is the bottom. The plate is copiously doused with a solution of chloride of zinc, and when heated to the proper degree molten lead in sufficient quantity is poured upon it.

Although the promoters of this process do not so call it, it is, nevertheless, soldering, which is authoritatively defined to be "the process of uniting two pieces of the same or of different metals by the interposition of a metal or alloy, which, by fusion, combines with each."

Here the metals to be united are lead and iron; the "metal or alloy" is zinc, or zinc and lead. I emphasize this simple matter because it is claimed that in the Graham process the two metals are united by a special alloy of lead and iron.

I quote from the company's courteous, well posted expert:

"Our boiler obviates these defects and overcomes the difficulties and repairs and constant inspection to which ordinary lead-lined boilers are liable. This is because the lead is united to the iron or steel uniformly by means of an alloy at the point of junction between the steel and lead, and the crystals of the two metals are intimately mixed at the point, so much so that it is impossible with a cold chisel to cut the lead away from the iron or steel without still leaving a thin surface of lead. The junction alloy of steel and lead has also a greater breaking strain than lead itself, it having been subjected to breaking tests."

A standard authority states that "an alloy is a combination by fusion of two or more metals, as brass and zinc, tin and lead, silver and copper," etc. Hence to speak of "the junction alloy of steel and lead" is incorrect, for in the coating operation there is not even an approximation to the melting point of iron.

The alloy of lead and iron appears to be almost unknown in the arts; and that this so-called "junction alloy of steel and lead," or, as I think, of zinc and lead, should possess a greater tensile strength than the lead is not strange, it is not an unusual property of alloys; thus one consisting of 12 parts lead and 1 part zinc has six times the tenacity of lead.

I must also put on record my lack of faith in the natural inference that would be drawn from the claim that the two metals (iron and lead) are intimately mixed at this point (the junction or cementation surface), "so much so that it is impossible with a cold chisel to cut away from the iron or steel without still leaving a thin surface of lead." Under favorable circumstances the lead can be "peeled" from the iron—I have done it myself.

I examined the Graham process after the Ritter-Kellner at Cornwall, and it struck me at once as a logical consequence that if "tacking" the lead on in places only gave satisfactory results, then complete cementation ought to do even better. Upon reflecting, however, I modified this hasty conclusion—for the governing conditions in the two processes are entirely different. In the Ritter-Kellner the lead is burned to the circular and vertical tenons.

Burning is defined as "joining metals by melting their adjacent edges, or heating the adjacent edges and running into the intermediate space some molten metal of the same kind." A well known writer says:

"The articles burned together being homogeneous, the parts expand and contract evenly by changes in temperature; the solders have a greater range of expansion by given changes in temperature than the metals they connect.

"The solders oxidize more or less freely than the metals they connect, and establish galvanic currents which destroy the integrity of the joint, especially in the presence of heat, moisture, or acids."

One would almost suppose the author had sulphite digesters in mind.

In the Ritter-Kellner there is little danger of the joints loosening. In the Graham, under periodic expansion and contraction and galvanic action, I should fear a sundering between the lead and iron; if this did take place, the boiler would very soon become unserviceable. Even granting the claim that the lining and sheet are indissolubly connected by an alloy of lead and steel, and that the "lead being the weaker metal, when fastened homogeneously to the iron or steel, has to obey the expansion and contraction of the iron or steel," there still remains an apparently insuperable difficulty. The lead lining is at least half an inch thick, and even supposing that the cylindrical laminæ in homogeneous contact with the iron are docile, and move in military cadence with their inseparable stronger companion, yet the balance of the lead must be subjected to a recurring ebb and flow for which no compensation is provided. I quote from the Graham expert:

"The explanation of the iron controlling the lead expansion is easy to understand. Lead is a very malleable metal, its crystals fitting loosely together, *i. e.*, there is comparatively a large space between the crystals as against other metals, and if the crystals of lead were counted over 22 feet (the length of the digester), and the number divided into one-third of an inch (the linear expansion of lead for 90 degrees in 22 feet), it would be found that the fractional part of this one-third inch would be considerably less than the space between each crystal, and there is no chance of one crystal pushing another one, as in metals where crystals are closer together."

On this theory I do not understand why lead should expand measurably under ordinary increase of temperature. Further, the common experience of every plumber militates against the correctness of the assumption.

Lead pipes for hot water will "creep" under fluctuation of temperature without perceptible increase of length; this is very evident when the pipe under a metallic clamp is examined; a burnished band is seen protruding beyond the clamp. I have seen this in less than twenty-four hours after brand-new pipes were installed.

It is a well known fact that in hotels, for instance, where a large quantity of hot water is used in the morning and very little during the rest of the day, the pipes being thus subjected to frequent and comparatively great changes of temperature, this very movement of which I have spoken, to use plumbers' parlance, "kills" them. That is, they lose all elasticity, become brittle, and crack, showing a crystalline fracture. Now, I am inclined to think that there is danger of such a result with the lead lining of the Graham boiler, even if the cementation remain intact. The lead, under this constant, enormous molecular stress, will degrade, become brittle, porous, crack, even drop off. (See Note 1.)

Then the boiler is ruined, for the lining, under such circumstances, can neither be repaired nor replaced.

Although I have not seen the patents issued to the Graham Company, yet I am of the opinion that they can afford but slight protection. The lead coating of iron has long been well known in the arts, as seen in terne plates, and no modern patent can limit the amount of lead that may be applied.

BRICK LINING—THE MITSCHERLICH.

The Mitscherlich digester, as already stated, is lined with an acid-proof brick of special design, laid in Portland cement.

Apparently a startling innovation, reflection proves that this method follows out the direct line of modern progress. The manufacture of that almost indispensable article, sulphuric acid, has in comparatively late years been greatly improved and facilitated by the introduction of the Gay-Lussac and Glover towers, edifices lined, not with lead, but with acid-proof tiles or brick. It is a curious coincidence, in this connection, that about seven years ago one of the leading American sulphuric acid makers told me that he had found that Seltzer jugs made the most resistant tower linings. The transition from brick-lined towers to brick-lined digesters must have been no difficult task for so able a scientist as Dr. Mitscherlich.

The ability of fire clay to withstand enormous stresses is familiar to us all. The Bessemer converter and the open-hearth furnace are illustrations in point.

The coefficient of expansion of fire-brick is only about 40 per cent. that of iron; in a length of 40 feet for a change of 180 degrees Fahr. a fire-brick construction would expand linearly less than one-quarter of an inch. Mortised and tenoned together, due to the special form of brick used, and laid in Portland cement, it constitutes a homogeneous mass, whose integrity is not jeopardized by usual fluctuations of temperature.

I have examined, with the utmost care, digesters that have been in use for nearly two years, and have failed to discover any intrinsic defect in the lining. The best steam boiler imaginable is liable to blow up if not handled with ordinary care, and so doubtless must an average degree of watchfulness be exercised in the use of the Mitscherlich, as well as of any other digester. An absolutely automatic digester, that fills, cooks, empties, and cleans itself, is still an undiscovered desideratum. The cement joints are now and then superficially percolated by the acid solution; they give clear warning of this percolation by discoloration; a cold chisel to cut out the affected mortar, and a trowel to repoint with cement, afford a ready, inexpensive, efficacious remedy.

In one of the digesters I noticed a patch back of one of the upper man-holes. The cause of the corrosion was very apparent, and its occurrence inculcated a valuable lesson. The man-hole is lined with lead. This is "bent under," flanging well back of the intersection of the man-hole cylinder with the digester. The brick lining comes up to this well, and, of course, has an open circular junction line, which must be kept well pointed, as at present constructed. This was neglected, the liquid penetrated, followed the lead, and ate its way through the iron. Such an accident can only occur under long-continued, persistent neglect.

I know of no engineering objection to a brick or tile lining for a low pressure digester. Such constructions, as already stated, do withstand extremes of temperature; indeed, on the Continent air-tight tile stoves are in general use.

UNLINED DIGESTERS—THE SCHENK.

The Schenk digester is a stationary, upright cylinder, 7 feet in diameter by 22 feet height, and is made in sectional castings of deoxidized bronze, with planed flanges, which are bolted together and lead-jointed in assembling. This alloy the designer assumes is sufficiently acid proof for the purpose, without the protection of other resistant lining.

Absolutely homogeneous kalchoid alloys are not of usual occurrence in manufactures; liquation, the presence of copper oxides, and occlusion of gas militate against the production of constant results. I take it that "deoxidized" bronze is the outcome of a process that hopes for uniform, reliable castings.

The value of phosphor-bronze in the arts is well established, and it is used in all the lead-lined digesters for the steam inlets that are immersed in the acid solution. In every case these inlet pipes are in time consumed.

I am not prepared to admit, after such examination as I have been able to make, that deoxidized bronze is superior as an acid resistant to phosphor-bronze. From the little that I have gleaned, it is claimed that it casts more surely in large masses. Even from this standpoint, aluminum bronze will probably be found to be more reliable.

I mention phosphor and aluminum bronze because there is no patent *per se* upon the Schenk digester; the only protection claimed lies in the fact that the company enjoys the exclusive right of making digesters of deoxidized bronze; hence, should any other copper alloy be found equally available for the purpose, no impediment exists to its free use.

It is acknowledged that the deoxidized bronze is acted upon by the acid solution, and observation confirms this conclusion.

The upper portion of the digester, the only part that could be examined on account of the chip filling, was coated with black oxide of copper, and both liquid and fiber hold it in solution or suspension.

It is claimed that this erosion is so slight that the longevity of the digester is not threatened thereby. This, of course, is a matter of individual opinion.

The digester we entered at Appleton showed extensive and deep honeycombing in the throat; we were told that this was due to bad casting. Without this information I should have come to a very different conclusion.

As I understood, one of the claimed valuable attributes of deoxidized bronze is that it makes sound castings.

It hardly seems judicious to use so unsound a section in an entirely new apparatus, designed as the foundation of a great manufacture. The pittings looked to me like the usual erosions manifested when corroding liquids or gases move over bronze surfaces.

Owing to liquation, more soluble alloys occur in spots, and the eating out of these produces the typical pitting.

The base section of this digester either had been, or was to be, replaced; the top section I would call in unserviceable condition; at both these places the bronze is exposed, in blowing off, to moving liquid and gas.

Copper-tin alloys are "kittle-cattle." All authorities agree in testifying to their sensitiveness. (See Note 2.) Fluctuations in temperature affect their strength, and their constant exhibition under active circumstances in the presence of sulphur compounds cannot fail to produce deleterious effects. (See Note 3.)

It certainly is not customary in permanent engineering constructions, built to withstand continuing, constant strains, to use material that is subject to uncontrolled, cumulative, indefinite wear or abrasion.

ACID PROCESS.

The manufacture of the bisulphite solution may be classified under three heads: The vacuum process, the modified tower process, the tower process.

I will dwell but briefly upon this matter, confining myself to evident features that would impress the average intelligent observer.

The vacuum system is used in connection with the Partington, the Schenk, and the Graham processes. It requires large exhaust pumps, a series of tanks arranged vertically in echelon, a lime mixer, etc., and undoubtedly yields with certainty the high solution required. It can unquestionably be used for all the processes. The best plant I saw was at Birmingham, copied from the English Partington, and costing here about six thousand dollars for the entire installation.

The modified tower system in use with the Ritter-Kellner process at Cornwall is a sort of cross between the Mitscherlich tower and vacuum method. The solution is pumped by a battery of pumps into a series of low towers under cover, filled with limestone. It did not strike us as possessing merits over the vacuum method.

The Mitscherlich tower process is in a measure automatic and is certainly the most economical.

The sulphurous acid gas is drawn up the high towers, filled with limestone, by atmospheric draught, and therein meets water trickling through the filling. Its main disadvantage is the assurance of proper draught. It strikes me that the application of a little American engineering skill would speedily bring about reliable and satisfactory results.

The consumption of sulphur varies from 200 pounds per ton of fiber in the Mitscherlich up to nearly 600 pounds in the others. In none of the others is it less than 350 to 400 pounds.

MECHANICAL PREPARATION OF THE WOOD.

All the processes, except the Mitscherlich, use chips. In this latter, disks cut out from the log, 1¼ inches deep, are used.

Dr. Mitscherlich claims that these disks afford a stronger fiber, and that more bulk can be put into the digester, than if loosely piled chips were used. One great disadvantage connected with the use of disks is that even if the finest cross-cut saws are used, circular or band, at least ten per cent. of the wood is wasted in sawdust. Further, more time must be consumed in

charging the digester. All this is a mere question of dollars and cents. There is no absolute objection to using chips in the Mitscherlich process; wood would be saved, labor economized, and time of boiling probably shortened. But, it is claimed by the professor, the output is not so good. Hence, if the better product earns more, even at the expense of material, labor and time, than the so-called inferior, why of course it would pay to follow Mitscherlich's recommendations. It would not be a very significant item of expense to be prepared to use both disks and chips.

(*To be continued.*)

PIAT'S PORTABLE FURNACES.

MR. A. PIAT exhibited in class 48 of the exposition his system of portable oscillating furnaces, that had already appeared in their novelty at the exposition of 1878. These furnaces have received notable improvements that adapt them to the melting of bronze as well as of cast iron. They are of boiler plate, and, as shown in Fig. 1, are square, a shape that permits of effecting a great saving in fuel, as the coke lodges in the corners, and the part of the crucible tangential to the sides of the furnace can, without inconvenience, be very close. A steel band provided with trunnions surrounds the furnace at a proper height to allow it to be tilted easily in either direction by means of a lever. It is by means of these trunnions, upon the shoulder of which is mounted an iron handle, that the furnace is raised by means of a lifting apparatus. A spout in front permits of discharging the molten metal.

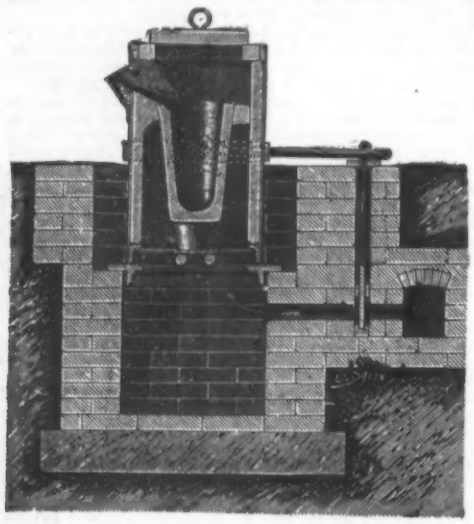


FIG. 1.—SIMPLE FURNACE.

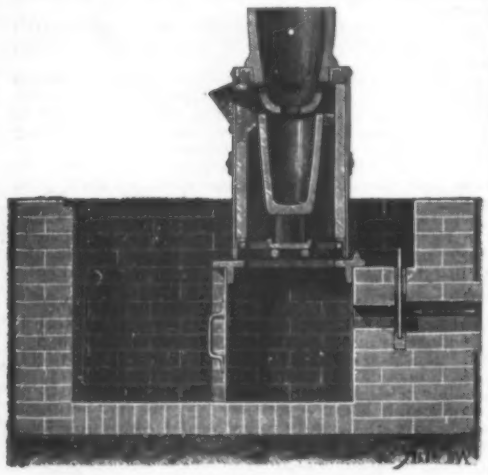


FIG. 2.—DOUBLE FURNACE.

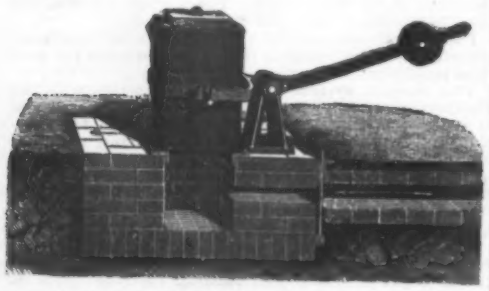


FIG. 3.—FURNACE OSCILLATED BY A LEVER.

The base of the furnace is formed of angle irons that receive the refractory lining. These angle irons are provided with sockets in which are adjusted two round bars designed to receive a part of a steel grate and four or six bars, according to the size of the furnace. These bars are allowed a certain mobility that permits of varying their spacing in order to facilitate cleaning and the exit of the scoria.

A support made of plumbago receives the crucible, which is adjusted at the spout against a piece made of refractory clay. This piece forms a part of the body of the furnace into which it is set. At the part exactly opposite the spout there is inserted a refractory clay wedge, in order to keep the crucible in place. The furnace is then ready to receive the fuel.

As refractory clay is not adapted for the manufacture of crucibles of over 200 lb. capacity, plumbago crucibles are especially employed in these furnaces. These are very simply mounted. The crucible is placed upon a plumbago support of the proper height, and is connected with the spout by means of a mixture of refractory sand and plumbago. At the first firing, the spout and the crucible are firmly united. The air introduced beneath the crucible should have a pressure of from 12 to 18 cm. of water.

With this arrangement, copper and its alloys are no longer introduced directly into the crucible, but rather into what is called a "*rehausse*," an arrangement (Fig. 2) that permits the flame to attack the metal directly and to melt it much more quickly without affecting its quality. This device, which much resembles a crucible, contains an aperture in the bottom, and, in the circumference, at a proper height, there are several other apertures. At the top there are two apertures that serve to put the rehausse in place on the furnace and to remove it, through an iron bar. The whole of the metal to be melted is put in succession into this rehausse, and all the crucible has to do is to receive it and keep it at the heat of fusion. With this style of furnace, 220 lb. of bronze can be melted in from 20 to 25 minutes, and with a mean supply of coke that ought not to exceed 15 per cent.

When the fusion is finished, the rehausse is raised and the adjustment of the crucible is examined, and if the metal is all right, the air is shut off.

In establishments in which space does not permit of installing cranes or other lifting apparatus, the furnaces may be mounted upon cast iron frames and be made to oscillate upon trunnions (Fig. 3) in the direction of the spout in order to pour the metal into a ladle, or backward in order to clean them. They can even be turned completely around in order to clean the grate thoroughly.

They may also be mounted upon a special apparatus, such as shown in Fig. 4, and which gives the workman a free space around the furnace.

The furnace just described is adapted for the melting of copper and all its alloys, and, when combined with a small cupola, to the melting of cast iron. This arrangement is shown in Fig. 5. The cupola, which is of small dimensions and has an aperture in the bottom, is placed upon the furnace and is carried by a hollow column which serves also as an air conduit. The introduction of the air is regulated by a cock. When the metal is melted, a screw permits of slightly raising the cupola, which then turns freely in its socket.

This apparatus is very convenient for making castings that require no more than from 220 to 650 lb. of metal. It permits, too, of making special mixtures that may be needed in certain cases. As the metal traverses only a very thin stratum of coke, and falls scarcely melted into a crucible raised to a good temperature by means of an ordinary blower, it has not the time to take impurities from the coke, and preserves all of its qualities. This device serves likewise for casting brass filings into ingots.—*Revue Industrielle.*

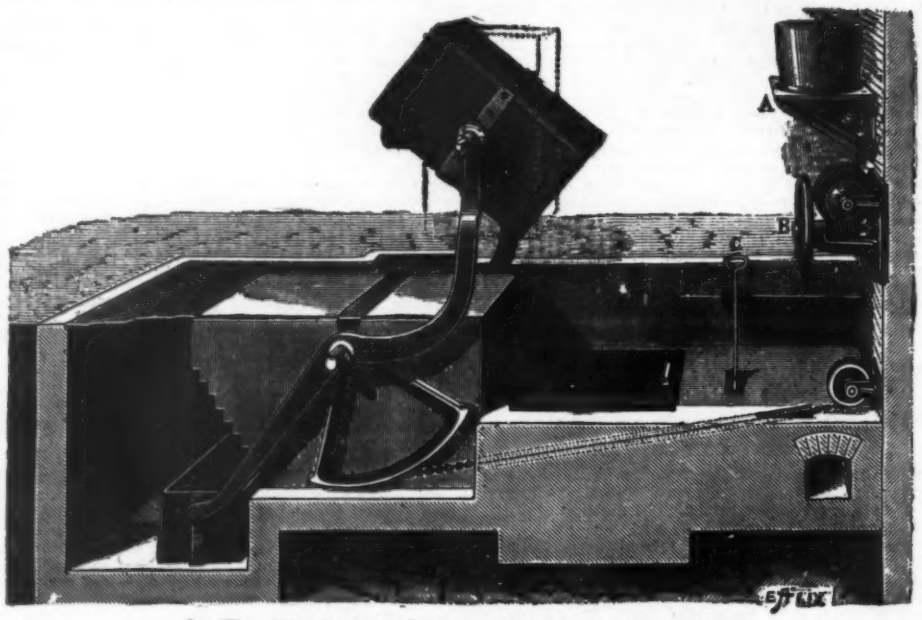


FIG. 4.—FURNACE WITH SUSPENSION APPARATUS.

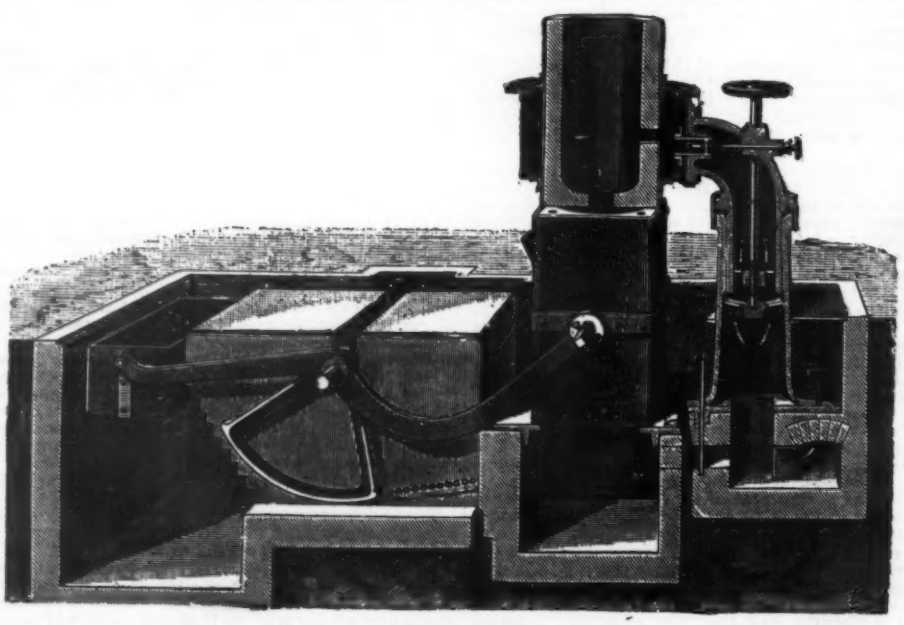


FIG. 5.—FURNACE WITH CUPOLA.

CALIFORNIA BORAX.*

By C. NAPIER HAKE.

Features of the Region.—Between the Sierra Nevada, on the west, and the Rocky Mountains, on the east, and from 35° N. lat. to the Columbia, may be found a succession of interior depressions of a particular character, inasmuch as the rivers and watersheds do not empty themselves into the sea, but are absorbed by the sands of the great desert or lost in the salt lakes. The most remarkable of these depressions, which is known as the Great Basin, is situated from 4,000 to 5,000 feet above the sea-level and occupies an area of 202,500 square miles. Its form is almost a square and its diameter from east to west about 500 miles. Surrounded on all sides by lofty mountains, its lakes and rivers have no visible communication with the ocean. Partly arid and scarcely inhabited, the feature of this vast country is that of a wilderness.

The interior of the Great Basin is dotted with mountains of a uniform aspect, each rising abruptly from a base of from 9 to 20 miles in circumference, to a height varying from 2,000 to 5,000 feet above the plain; their slopes are covered with trees and verdure, and their summits are capped with snow during the greater portion of the year. This on melting causes innumerable torrents, which are afterward lost in the lakes or sucked up by the sand.

Another grand characteristic of these deserts is the phenomenon caused by the river rolling with a crashing noise through the enormous ravines which the Mexicans call *canons*. These ravines, which are often impenetrable, are hollowed out by the action of the waters to a depth of 300, and even in some places 900 feet, their faces being usually quite perpendicular and so close that you could easily cross from one bank to the other by means of a bridge a few yards in length.

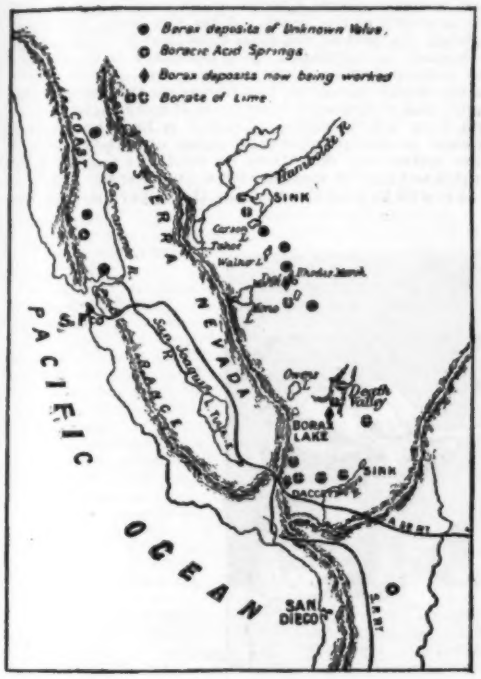
Among the rivers irrigating the Great Basin, the

* A paper read before the London section of the Society of Chemical Industry.—From the *Journal.*

finest is the Humboldt. This river has two branches, which take their source in a group of mountains situated to the west of the Great Salt Lake. After a course of 55 miles the two branches unite in one bed. For upward of 300 miles no obstacle whatever impedes its course and no tributaries run into it. As it advances toward the west it gradually loses part of its volume, owing to the absorption and evaporation of its waters, and finally is lost near the Sierra Nevada in a muddy lake or "sink," the borders of which are flat and whitened by saline incrustations.

The other rivers of the Great Basin on the west are the Salmon River, which flows into Lake Pyramid, the Carson, the Walker, and the Owen, which descend with a terrific noise from the Sierra Nevada, and then disappear in lakes to which these rivers give their name.

Such is the general aspect of these deserts. Except in certain valleys where fertility and beauty afford a most striking contrast to their bleak surroundings, the soil is to all intents and purposes sterile. It is chiefly composed of the debris of volcanic rocks. Beds of lava rich in soda feldspar cover the country to an extent of many miles; the rain in its season falling on these causes their superficial decomposition and gathers up the soluble salts in its passage. Owing to the general dryness of the atmosphere which prevails, however, for the greater part of the year, evaporation follows solution, and whatever is dissolved tends to rise to the surface, there to crystallize and form what are called efflorescent crusts. These crusts, which at times measure from one foot to 18 inches in thickness, the rain again dissolves away, and if the region contains natural depressions or basins these are transformed into saline lakes. The saline deposits or incrustations so largely distributed over this great plain include common salt, carbonate of soda, sulphate of soda, sulphate of alumina, sulphate of magnesia, borax and borate of lime, sulphate of lime, and carbonate of soda and lime, etc.



Borax Deposits in Northern California.—The first deposits of borax discovered in California are situated in Lake County, about 100 miles north of San Francisco. Some of these deposits were worked successfully between 1864 and 1874, but they now lie idle.

Discovery of Borax in Nevada.—The history of the discovery of borax and borates in Nevada may be briefly summed up as follows:

In 1864 some borate of lime in the form of cotton balls (ulexite) was found in Columbus Marsh, but no particular notice was taken of this discovery beyond sending specimens to Washington, where they found a place in the cabinet of the State Museum. Between 1869 and 1871 a systematic search was made, which resulted in the rediscovery of the deposits in Columbus Marsh and other deposits of ulexite near Salt Wells. These deposits were worked for a short time only. In 1873 the deposits known as Borax Lake and Teel's Marsh were discovered. The former lies in the Mojave Desert, the latter in Nevada. Both deposits are very extensive. A little later a third deposit was discovered near Dagget, consisting of borate of lime (colemanite).

Situation of Borax Lake.—The Borax Lake, which specially interests us this evening, is situated in the extreme northwest corner of San Bernardino County, and is 450 miles distant from San Francisco in a southeasterly direction.

Mojave station, on the Atlantic and Pacific Railway, the nearest point of shipment, is connected with the lake by a good wagon road, 72 miles in length.

The lake lies in the valley of the State Range and Argus Mountains at an elevation of 1,700 feet above the sea. It is oval in shape and its greatest length and breadth is 12 miles by 8 miles. The greater part of it is covered with a hard saline incrustation varying in thickness from a few inches to several feet. The surface is covered with white efflorescent matter largely mixed with sand. Under the hard crust the lake consists of one vast bed of black mud containing a large proportion of iron sulphide saturated with saline matter and strongly impregnated with sulphureted hydrogen gas. The thickness of this mud bed has not been determined.

In the lake is contained common salt, carbonate of soda, hydrated and anhydrous bicarbonate of soda, biborate of soda, sulphate of soda, hydrated and anhydrous sulphate of magnesia, salts of ammonia, and traces of bromine and potash. Although I made a diligent search during the four weeks I remained on the lake, I was unable to detect a trace of iodine. A new and highly interesting mineral has been discovered in the mud of this lake in small hexagonal crystals, to which the name of "hanksite" has been given, after Professor Hanks, of San Francisco, whose name is so honorably connected with the mineral development of California. Its composition is expressed in the formula:

$$4\,Na_2SO_4,\ Na_2CO_3.$$

The lake may be for all practical purposes divided into three sections, each section representing well defined deposits of—

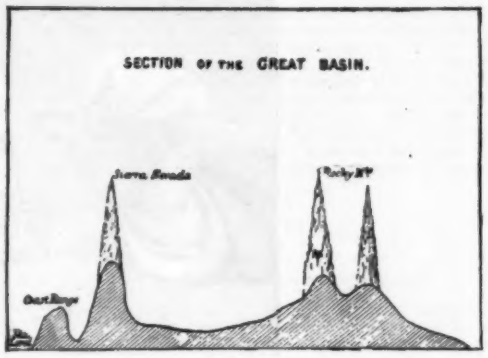
(1) Biborate of soda,
(2) Bicarbonate of soda, and
(3) Common salt.

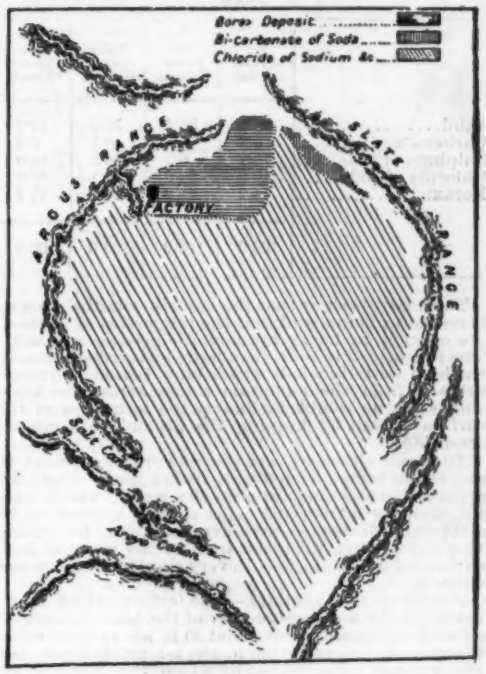
The borax occupies the northern portion of the lake. A very pure deposit of bicarbonate of soda lies on the N.E. shore. The remaining surface deposits consist chiefly of common salt, which becomes purer toward the southern extremity of the lake.

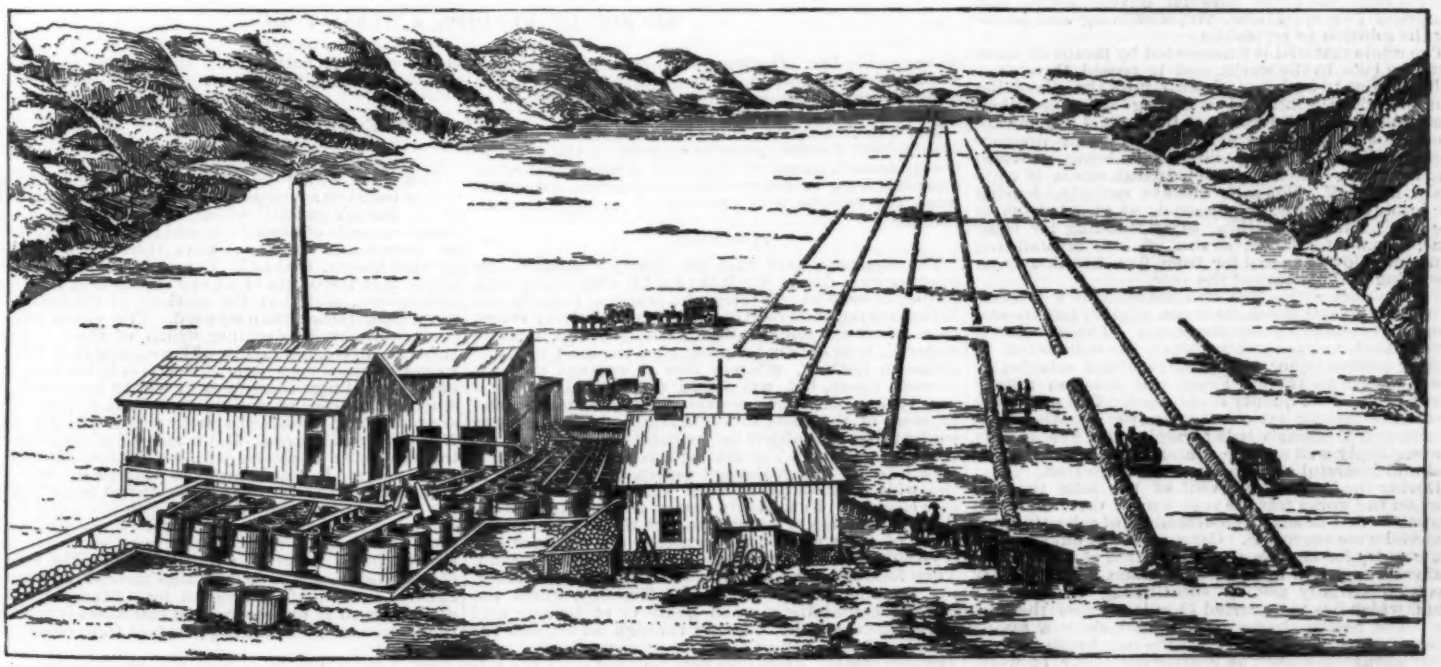
The common salt and bicarbonate of soda deposits have at present no commercial value. The latter is, however, of considerable interest as an example of the ammonia soda process being carried on by nature. All the ingredients necessary for this process are contained in the waters underlying the deposit, viz., ammonia, carbonic acid, and common salt. The deposit is from 6 in. to 18 in. thick, and in many places almost chemically pure.

Crystal Beds.—Near the center of the borax section, which is the lowest level of the lake, there exists a patch covering an area of about 300 acres, which is nearly always covered with water to a depth of from one inch to a foot. This patch is called "the crystal bed," from the fact that the mud underlying the water is full of large crystals. These crystals are not deposited regularly, but form nests several feet in thickness, and penetrating 3 or 4 ft. downward.

The spaces intervening between these nests are filled up with mud, and are comparatively free from crystalline deposit. By damming off the water I was enabled to make an examination of some of these nests. The crystals thrown out consisted of carbonate of soda and common salt, with a large proportion of borax, some of the crystals of which measured as much as 7 in.







GENERAL VIEW OF THE BORAX LAKE AND WORKS.

During one exceptionally dry season, when the water was low, about 700 tons of borax were refined from this source.

The underlying water at a depth of fifteen feet contains:

Carbonate of soda,
Chloride of sodium,
Sulphate of soda,
Borax, and
Salts of ammonia.

The ground around this crystal bed consists of a dry, hard crust about 1 ft. thick. This crust contains carbonate and sulphate of soda and about 1 per cent. of borax. On this hard crust there is, again, another deposit of efflorescent matter, containing about—

	Per cent.
Sand	50
Sulphate of soda	16
Common salt	12
Carbonate of soda	10
Borax	12

This surface deposit represents the chief source of raw material for the manufacture of refined borax.

The deposit is worked in the following manner:

Method of Working Deposit.—When the crude efflorescent surface has accumulated to a depth of about 1 in. in thickness, it is loosened by means of a shovel and swept into windrows, space being left between each windrow to allow of the passage of a cart.

The surface thus cleared of its salts begins to renew its coating. The moisture, as it creeps upward, is evaporated by the heat of the sun, leaving the solid matter, which is held in solution on the surface. This action is allowed to go on for three or four years before the surface is again disturbed. In order to get some idea as to the proportionate growth of the different salts contained in this efflorescent matter, I took samples representing 6 months' growth, 2 years' growth, 3 years' growth, and 4 years' growth. From all the sections from which these samples were taken, the surface has been removed three or four times during the last 12 years, and in most places marks of the old windrows were visible.

ANALYSES OF CRUDE BORAX MATERIAL FROM DRY LAKE.

	Six Months' Growth.	Two Years' Growth.	Three Years' Growth.	Four Years' Growth.
Sand	58·0	55·4	52·4	53·3
Carbonate of soda	5·2	5·0	8·1	8·0
Sulphate of soda	11·7	6·7	16·6	16·0
Chloride of soda	10·9	20·0	11·1	11·8
Borax	14·2	12·9	11·8	10·9
	100·0	100·0	100·0	100·0

The analyses show that the first six months' growth is richest in borax, and that the proportion of carbonate of soda to borax appears to increase regularly. The presence of sand in such large quantities is due to the high westerly winds which blow periodically, and drive it from the mountain slopes across the lake. This sand, no doubt, facilitates the formation of the surface deposit by keeping the ground in a porous condition.

That only this section of the lake produces borax to any extent is due, no doubt, to its low level. The hard crust above mentioned dips in the water, which rises by capillary attraction. This contact appears to be a favorable if not a necessary condition, for during very dry seasons, when the level of the water is low, surface recuperation goes on very slowly, or even ceases entirely.

Process of Manufacture.—The factory, which is situated on the northwest corner of the lake, consists of a dissolving house raised about 20 ft. above the level of the ground, concentration house, a refining house, and boiler house. The process by which the borax is extracted from the crude material is very simple, and comprises two operations, viz., dissolving and allowing the solution to crystallize.

The crude material is transported by means of carts from the lake to the works, and is passed through a mill previous to its being thrown into the dissolving pan, in which is contained a boiling saline solution, preferably mother-liquor, from the second crystallization. The solution is kept boiling by high pressure open steam as the crude material is being shoveled into it, during which operation free ammonia is copiously given off. The salts dissolve entirely, leaving the insoluble residue, chiefly sand, at the bottom of the pan. The hot solution, after standing for some time, in order to clarify, is run off into crystallizing pans and allowed to cool for from five to nine days, according to the season of the year.

The product of this first crystallization is a mixture of octahedral and prismatic borax, slightly impure and somewhat colored by organic matter. This product is either sold as "concentrations" or redissolved in boiling mother-liquor and the resulting solution allowed to cool to 120° F. From this solution refined borax of excellent quality is obtained. The works are capable of turning out over 100 tons per month, about 50 men and 65 animals being employed. The factory is exceedingly well arranged and substantially built, and under careful and intelligent management.

During the time of my visit at the lake the fuel used on the works was the sage brush, the only wood growth in this desert. The difficulties of collecting this material were enormous. Carts were sent out scouring the country for 10 miles round in search of fuel, and remained away often for a week at a time. This difficulty has been partially met by substituting crude petroleum, which has to be carted 72 miles across the desert. The results, however, I am told, show a saving of nearly 40 per cent. as against the sage brush, besides other advantages, such as greater regularity of working.

Water Supply.—The question of water supply is an extremely interesting one. The water is obtained from two sources. The one which is used for drinking purposes and for feeding the boilers is brought in iron pipes from a canon lying in the Argus range, 7½ miles distant from the work, at an elevation of nearly 300 feet. This canon, which forms an oasis in the desert, contains several springs, and where cultivated yields an abundance of fruit and vegetables.

The other supply is derived from artesian wells which are sunk to a depth of 55 feet on the shores of the lake. The water rises from 3 to 10 feet above the surface, and the flow is constant and regular.

This water is strongly alkaline, containing about 1 per cent. of carbonate of soda, strong traces of borax, and salts of ammonia equal to about 18 grains per gallon.

Labor.—The question of labor presents no difficulties; all common operations are carried on by Chinamen, and this class of labor can be procured in California at a comparatively moderate rate.

Transport.—The refined borax is packed in casks and transported to Mojave, in the so-called "desert schooner," a strongly built wagon drawn by 20 mules. The average load is 10 tons, and the trip to Mojave and back takes eight days. The road through the light sandy soil of the desert rises gradually 1,000 feet during the first 25 miles.

This road is controlled by the owners of the lake, who possess the right to the water, which is supplied to the four roadside stations through iron pipes from a range of mountains 10 miles distant. These stations afford sleeping accommodations for the teamsters and stabling for the animals.

During my visit to California I took every opportunity of making myself acquainted with the extent and value of the borax deposits in the Pacific States, and I gathered that, though widely distributed, there are only three deposits of any great importance which are actually being worked at the present time. These deposits yield from 1,500 to 2,000 tons of borax annually, nearly the whole of which is consumed in the United States.

The lake which I have described has been regularly worked for the last 15 years under the direction of Mr. J. Searle, the chief owner, who is known all over California as the keenest bear hunter in the State; but he is not less known for his hospitality, high integrity, and intelligence. During this period it has supplied about one-third of the total amount derived from similar sources and with considerable profit to the owners. The supply of borax on this lake appears to be practically inexhaustible, and it only requires improved means of transport for its full development.

In conclusion, it may be of interest to briefly allude to Death Valley, which lies 400 ft. below the level of the sea. Borax and borate of lime deposits have been discovered and worked in this valley, which is probably the most desolate and least explored of any portion of the United States. The climate, owing to the intense heat and dryness of the atmosphere, is almost unbearable. It is absolutely devoid of either animal or vegetable life. During several months in the year work has to be suspended, one reason being that the solution would not cool down to a temperature at which crystallization takes place.

The communication which I have made to you this evening will, I trust, prove of interest to the society, if only as an instance of what can be accomplished in manufacturing chemistry under stupendous difficulties when the enterprise is directed by intelligent perseverance.

DISCUSSION.

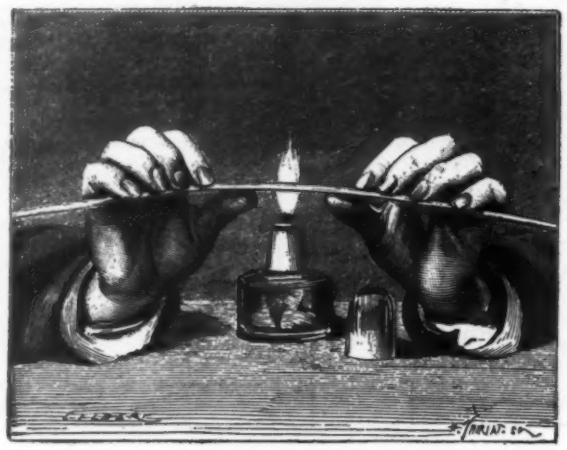
The chairman said that the hearty thanks of the meeting were due to Mr. Hake for his able paper on a subject of very wide interest and practical importance. When one remembered that, at a comparatively recent date, borax was selling at 90*l.* a ton, and was a costly material, used chiefly for producing the most valuable glazes on pottery, whereas now it was not only extremely cheap, but was found to be available for a vast variety of purposes—even running a good second to some of the most widely advertised soaps—it was evident that the subject before them had an important practical bearing. The matter also possessed considerable interest in a geological aspect, as an example of the wide distribution of what was once considered a rare element. In the early part of the present century the only sources of borax were the tincal lakes in the north of India and Thibet, where it was obtained in a crystalline state from beds of semi-gelatinous mud. Then followed that triumph of technical engineering, the working of the *lagoons* of Tuscany, where the *suffioni* containing a small quantity of boracic acid were condensed by blowing through water, and the solution thus obtained evaporated down by the same volcanic steam. Italy thus became practically the sole source of the world's supply of borax, its product running the tincal deposits completely out of the market. Next came that singular deposit obtained from Peru, which in appearance closely resembled a very white potato; and lastly came this wonderful American deposit described by Mr. Hake, and rhodrate, the borate of lime of Turkey. Boron, therefore, instead of being an element of rare occurrence, as was once supposed, was found to be widely spread over different parts of the world. And its applications were likely to be equally wide. It was already known to be the finest of all glazes, a most useful detergent, and one of the most valuable of disinfectants, and its uses were not yet exhausted, seeing that this once chemical luxury was now cheaper than carbonate of soda was a few years ago. He was glad to see that Mr. Robottom was present. He could speak on this subject with more authority than any one else in Europe or America; and the meeting would, he was sure, be glad to have the benefit of hearing his views.

Mr. Arthur Robottom then gave the meeting a vivid and interesting account of his pioneer work in the exploitation of Californian borax; of his journey on foot at the rate of twelve to fourteen miles a day, and, disguised as a "busted" miner, across the 240 miles of sterile country lying between Los Angeles and the Mono Lake; his stay at Jim Bridger's shanty, his meeting with the pioneers John and Dennis Searle, and the shipment of the first cargo of natural borax to England; his high hopes of future profit from the trade, and his subsequent disappointment and trials on finding himself saddled with an immense quantity of borax, the selling price of which had suddenly declined from 90*l.* to 26*l.* per ton (a figure very little above the bare cost of transport), and which could not be readily disposed of even at that price, owing to the general ignorance of its many good qualities. Mr. Robottom concluded by expressing his conviction that the efforts which he had then made had given such a stimulus to the use of borax as could not fail to result in mutual benefit to traders and consumers.

BENDING GLASS TUBES.

WHEN one has some chemical apparatus to mount for an experiment, it is often necessary to curve glass tubes. In laboratories, chemists make use of gas burners, into the center of the flame of which air is blown. By means of the blowpipe the glass is worked very easily. But the amateur, or the professional in the country, has not apparatus of this kind at hand. In such a case, a simple spirit lamp may suffice by operating as shown in the figure. After the lamp has been lighted, the part of the glass tube that is to be curved is heated in the flame. It is necessary to be careful not to keep heating it at the same point, as this would surely break the glass, but to revolve the tube in the flame and at the same time move it from right to left and from left to right. When it is hot, the flame is allowed to act upon the same point, and the glass will soon soften and may then be bent. It may even be drawn out and be melted with a simple spirit lamp.

It is well to heat the tube in the upper part of the flame, which is hotter than the central part, and is what chemists call the oxidizing flame.—*La Nature.*



METHOD OF BENDING A GLASS TUBE.

CONVECTIONAL CURRENTS IN STORMS.

By H. A. HAZEN.

THE most widely accepted theory of storm generation is based on a supposed heating of a limited portion of the earth's surface, which, in turn, sets up convectional currents of heated air, and from these our severest storms and tornadoes have their birth. There is another theory, that of M. Faye, of France, which considers that the origin of all our storms is in the upper atmosphere, and that the motions at the center are downward rather than upward. The wisest will find great difficulty in deciding which of these opposite views is correct, and many will conclude that after all we really know very little of the facts in the case, and, until we do know these facts, it will be best not to put much dependence on any theory. Both of these views are now being published side by side in the *American Meteorological Journal*, and it may be of some interest to discuss the inferences with which theorists support their views. It would seem as though the time had long since passed for us to rest satisfied with "glittering generalities." Any theory which is not capable of being put into exact language, and of allowing a definite, quantitative, computation from cause to effect, may be justly regarded with suspicion. The number of educated men who believe that present theories are entirely inadequate to account for a tithe of the energy developed in our storms and tornadoes is constantly increasing. What are the proofs of this convectional current?

1st. "Many observers have recorded the visible upward flight of large objects." Surely we are not to infer that this flight is due to a convectional current, nor is it due to a rush of the body into a partial vacuum above it produced by such a current, for a partial vacuum would cause the object to cling to the earth all the more closely. In all cases, the object is borne along by a violent rush of air or of the wind, and we may seriously doubt that there is any convectional current at all, or its efficacy in producing such a result even if it were present.

2d. "The upward motion about the center of a tornado is, moreover, proved in the same manner as in cyclones, by the continued oblique indraft, for which there must be some upward escape." This is the great argument, above all others, which has been advanced to prove the necessity of an uprush of air at the center of a storm. It is almost universally conceded that air in a storm has a motion normal to the isobars at the outer edge, and, as it approaches the center, this motion makes an angle with the isobars becoming tangential near the center. It was shown in the *Am. Met. Jour.* for September, 1884, p. 174, that all this air cannot find its way to the center of the storm, but that it would "rise uniformly along the whole interior advancing circle of wind." Let us take a concrete example. Suppose the air circulates about a storm and toward its center up to a height of 4,000 feet, and that

above that height there is a uniform current from the west. Also let us consider that the radius of this circulation is 400 miles.

For the sake of simplifying the problem, let us consider that the air is blowing radially toward the center. Take a very thin cylinder or shell of air 4,000 feet high and 400 miles in radius. As it approaches the center it must be heaped up higher and higher, so that, neglecting for the present the current from the west, when this cylinder has reached within 200 miles of the center it will be 8,000 feet in height, and at 100 miles it will be 16,000 feet, and so on; but it is plain that the current at 4,000 feet would bear along all the surplus air until the center was reached. Since the motion is tangential at the center of the storm, we see at once that there is absolutely no need of an uprush of air to provide for the escape of the air, which only in imagination reaches the center. The evidence is very strong indeed that the storm is a simple whirl in the air, largely independent of the upper current, and there is no proof whatever that any air flows obliquely into the center.

3d. Another proof of this convectional current is this: "The heavy clouds—thunderheads—that accompany thunderstorms and tornadoes may be seen to boil upward distinctly enough, and are among the best indications of local overturning in the atmosphere." In reply to this, we may say: Dr. Henn, of Vienna, has shown that under these conditions there is a simple interchange of air between contiguous strata. That there is any transport of air *en masse* under these conditions is clearly disproved by careful observations.

While the extreme insufficiency of these enforced proofs is apparent, there are, in addition, insuperable objections to this theory of convectional currents.

1st. If there were such currents, the rain should fall at the center of the storm instead of 300 or 400 miles ahead of it.

2d. Thunderstorms and local outbursts should occur near the center instead of 400 miles southeastward and where there are no convectional currents.

3d. Sincet he upper part of this convectional uprush is in a current moving much faster than the lower part, its verticality, a condition absolutely essential to its maintenance, would be entirely destroyed in a few moments. The assumption that the upper part breaks away from the lower, and goes gyrating along in front, communicating these gyrations to the lower air strata through a frictionless medium, is suicidal to the continuity of the convectional current, and is, moreover, impossible from the very nature of things.

4th. Just exactly where the sun's heat should be the greatest it is warded off by clouds.

5th. Even if the sun's direct heat were acting, it could not be said that the effect was "local," for it uniformly heats a circle about 1,000 miles in diameter.

6th. That the sun's direct heat does not produce these convectional currents is abundantly proved by the fact that an increase at midday of 30° above the morning temperature does not bring about this supposed uprush.

7th. It is now known that the most important change in the atmosphere, on the approach of a storm, is the enormous increase of the amount of moisture in its front.

These changes occur in enormous circular or oval districts, amounting in some cases to 160,000 square miles. The velocity of these ovals is often 30 and more miles per hour. The amount of moisture is often doubled in front of a storm and diminished a like amount in the rear. At individual stations this change is often greater than this. For example; in Washington City, on December 22 of last year, the moisture diminished from 4·09 grains per cubic foot at 3:11 P. M. to 1·09 grains at 5:2 P. M. This was the most extraordinary fall noted in two years, and indicates a rapidity of change seldom thought of in the atmosphere. To determine the causes of these changes would seem of the highest importance, and this would throw a flood of light upon little known changes in the atmosphere. This change in the moisture cannot be due to increasing heat of the sun, for this often amounts to 30° during the day hours without affecting the moisture. It is not due to the wind, for it often occurs in a calm, and it would require a velocity very much beyond that experienced to bring about some of the changes. Moreover, very frequently the amount of moisture is less all about the region where the increase is taking place. It hardly seems probable that the change comes from above, for the air is drier there, and it is believed that in front of a storm, at least, there is an uprush of air. This change cannot be due to a transport or massing of moisture through the introduction of air or heat currents of any kind. Certainly the convectional hypothesis can give us no help in this matter. Are there peculiar conditions in a storm whereby moisture is attracted toward it from the soil and surrounding atmosphere? We know that in the center of a storm there is observed negative electricity in abundance, and this is specially the case during the fall of rain, while in the center of a high area, or during clear weather, the electricity becomes markedly positive. It is also known that particles tend to leave the positive pole and collect at the negative pole. Why may not we be dealing with an analogous phenomenon here? Why may not moisture particles be drawn from one portion of the atmosphere directly to another? These are surprising conclusions, but have much to support them. If they can be established, we have gone a long way toward explaining many mysteries in storm formation.

8th. If a storm has for its essential feature a partial vacuum at the center, brought about in any manner whatever, and this partial vacuum is transported by currents in the upper regions at the rate of say 30 miles per hour, is it not evident that no air could reach the center from the rear unless each individual particle had a velocity greater than 30 miles per hour? In this case the particle must travel in a radial line. If it moves in a spiral toward the center, its velocity must be greater than that of the storm. Now it is very rare indeed that the wind in the rear reaches half the velocity of the storm toward which it is blowing. Does not this show that the hypothesis that a convectional current, or any uprush of air, is needed to get rid of the oblique indraughts is a myth? It seems to me the proofs are almost overwhelming that a storm is not a partial vacuum fed by currents in a haphazard manner from outside, or produced by a convenien toverturning of air strata through a hypothetical heating just in front of the advancing storm and nowhere else, an impossible condition, but it has its own source of energy, independent of outside conditions, at least in the line of direct heat action from the sun.

Here, then, is the great battle ground of the new meteorology. Let us lay aside vague theories and "glittering generalities." Let us come to the full understanding, if possible, at this very threshold and fundamental hypothesis of the old school. Has not the time passed when men of this school can complacently say that the objections to their theories are puerile, and are advanced by men ignorant of physical laws, and especially of their own interpretation of them? What are needed most of all are carefully conducted observations of moisture, temperature, etc., in a vertical direction for 6,000 ft. Such observations would place all our discussions on a sure groundwork of fact, and would be a great boon to the science of meteorology.

Unfortunately, the fates have decreed thus far that the upper air must hold its secrets and that this region must remain a *terra incognita*. Hundreds of thousands of dollars are gladly given and many lives are lost in exploring the uninhabitable wastes of Africa and in the terrible starvation of the well-nigh impenetrable icy north, but here is a most fascinating field for research, just within our reach, at only a nominal expense, and without such great risks. Such an exploration would advance the cause of science and conduce to the saving of life and property probably in far greater portion than that lost in the other hazard, from which only fame can ever be expected. One point more:

The ordinary theory that the escape of latent heat of condensation in a convectional current must be used up in doing work in pushing aside the air which presses in on all sides, seems very unsatisfactory. This explanation certainly fails to explain. According to theory there is nothing like a vertical cylinder of air surrounding a convectional current, every point of which is pressing upon the latter. The whole mass of hot air, according to the old school, is rising and rotating like an enormous balloon, 6,000 ft. high and 100,000 to 3,000,000 ft. in diameter. Surely it cannot be claimed that in the center of this balloon any work has to be done in pushing aside the surrounding air. This whole theory of a convectional current in the center of a storm was propounded fifty years ago, when it was thought that the rainfall and all the more prominent disturbances were at the center of the storm, but it must be admitted that the proofs are exceedingly unsatisfactory, and it will be much safer for us to obtain more facts before insisting on any plausible theory.

Washington, January, 1890.

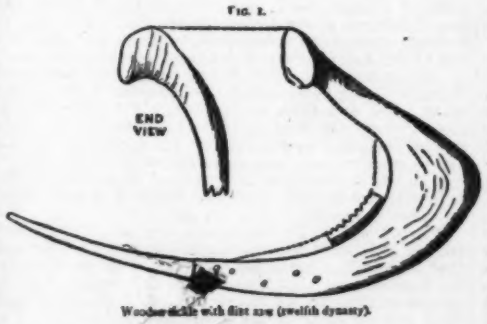
[NATURE.]

EARLY EGYPTIAN CIVILIZATION.

ALTHOUGH the paintings in the tombs of Memphis, of Beni Hasan, and of Thebes, have preserved to us the knowledge of much of the civilization of Egypt, yet hitherto we have handled but few examples of the implements used, and those are mostly undated. Broadly speaking, the three sites just named represent respectively the Old Kingdom before 3400 B. C., the Middle Kingdom about 2600 B. C., and the New Kingdom from 1600 B. C.; and though debarred from scientific work in these richest districts of Egypt—owing to national jealousies—I have been fortunate enough to discover two small towns, each only occupied for a couple of centuries, which have thus revealed the works of the Middle and New Kingdoms with chronological exactness. Besides the Egyptian interest of these places, they are of prime importance for Mediterranean history, having been colonies of foreign workmen.

These towns are one on each side of the entrance to the Fayum province, fifty miles south of Cairo. The northern town, now called Kahun, was built for the workmen employed by Usertesen II. for his pyramid and temple, about 2600 B. C. The southern town, now called Gurob, was founded by Tahutmes III., and destroyed by Merenptah, thus lasting from about 1450 to 1190 B. C. Obtaining thus two sites of different ages, close together, we can be certain that all differences are due entirely to time and not to locality. The change in an interval of 1,200 years is most marked. Of the pottery, scarcely a single type of form or material is alike in the two periods; of the many varieties of beads of stone and glazed ware, hardly

FIG. 1.



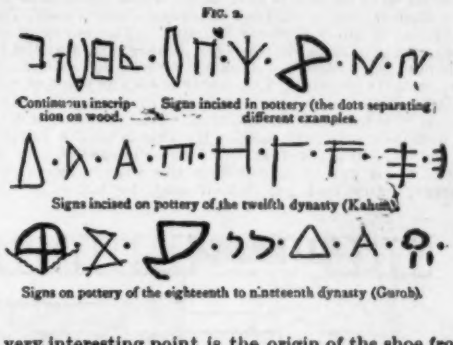
Wooden sickle with flint saw (twelfth dynasty).

one was continued; the metal tools are every one changed in form; and the use of flints had practically died out. For the first time we are able to trace the definite and decided changes in all the products of two ages so remote. The idea that Egypt was changeless is only due to our lack of knowledge; not only fashions changed—every few years in minor details—but radical rearrangements were made from age to age in the manufactures.

The twelfth dynasty town—Kahun—is the more important, and we will briefly note some of its products. Flint working was carried to a high pitch, the thin flat knives being flaked with much skill; but alloys of copper were also in use, and show ability in their casting and hammering, a thin bowl being wrought out of one piece. We find, then, flint and metal side by side, the flint being the commoner material, but yet influenced in its forms by the types of metal tools. Moreover, we now see the use of the numerous flint saws, formed of serrated flakes; many of them have black cement upon them, and one was found remaining in its socket in a wooden sickle (Fig. 1).

Besides hatchets, adzes, and chisels of bronze, we find needles, barbed and unbarbed fish hooks, netting needles, and knives of the straight-backed type. Among wooden tools are hoes, rakes, grain scoops, a brick mould, plasterers' floats, bow drills, plummets, etc. Perhaps the most important of all is a fire stick, on which five burnt holes remain where fire has been drilled by a rotating rod; the drilling was begun by hacking a groove in the side of the stick, down which the heated wood powder might run, until it caught a light. This shows, for the first time, how the Egyptians obtained fire; and familiar as they were with the bow drill, they doubtless used it for the fire stick.

FIG. 2.


Continuous inscription on wood.
Signs incised in pottery (the dots separating different examples.
Signs incised on pottery of the twelfth dynasty (Kahun).
Signs on pottery of the eighteenth to nineteenth dynasty (Gurob).

A very interesting point is the origin of the shoe from the sandal. Two sandal shoes have been found; both with toe and heel straps, but with an upper of leather across the foot. Tops, tip cats, clay toys, dolls with jointed limbs, and game boards, were all in use. Among a large number of papyri that I found are two wills, one of which is a recital of a will and a settlement, duly witnessed. The provisions show that the later law of Greek times was much the same in matters of descent as it was two thousand years earlier. On receiving family property, the man settles it on his wife; she has a life interest in the dwellings, and may divide all the property among their children at her discretion. The man's official position he left to his son. A guardian was also appointed, excluding the eldest son from that duty. Some numerical notes concerning fractions are also found; and all these papyri are in course of study by Mr. F. L. Griffith.

On returning to the later town—Gurob—of about 1300 B. C., we find that the art of flint working was lost; only a few rude leaf-shaped flakes (totally different from the earlier forms) and some little saw flakes remain, and these are scarce. Thus we may date the fall of fine flint manufacture in Egypt to about 2000 B. C.; though rude flakes continued to be used till late Roman times, and more abundantly in poorer ages. Bronze tools were much modified; hatchets and chisels less finely formed, knives always double-edged, fish hooks not barbed, and punched metal rasps were brought in. Bronze working reached a high level in the making of two large pans, 14 and 9 inches across, exquisitely wrought with difficult curves, and so thin that they can be still bent in and out by the fingers. Glass ornaments were commonly used, though not found in the earlier town. The plain beads of fine blue, violet, etc., belong to about 1300 B. C.; while the coarser beads of black, yellow, green, brown, and white, with eye patterns, are about a century later.

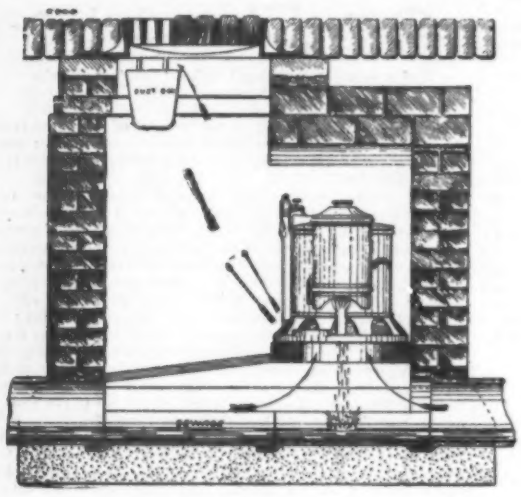
The presence of foreigners in both of these towns is shown by the weights discovered, which are—with scarcely an exception—of foreign standards, foreign forms, or foreign materials. A commercial intercourse must therefore have been kept up between these foreign colonies and the Mediterranean. Besides this evidence we find at Gurob the burials of one of the Tursha or Turseni (from Asia Minor), and a Hittite; foreign art is seen in a mirror handle with the Phœnician Venus, and a wooden figure of a Hittite; and foreign complexions are shown by the light hair found on some of the bodies. A very strong Mediterranean influence appears in the quantity of pottery identical with the earliest styles found at Mykenæ, at Thera, and at Mytilene; and we are now able to date those stages of early culture in the Greek lands to 1300 B. C., a fixed point of the greatest value.

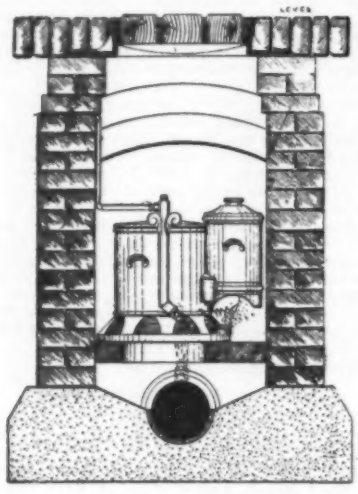
The most novel discovery of all is the presence of apparently alphabetic signs in use in both towns (Fig. 2), and by all the circumstances amply guaranteed to be of about 2500 B.C. and 1300 B.C. Our existing theories of alphabetic development require us to suppose that the Phœnician letters were established before 2000 B.C.; as the Egyptian writing from which De Rougé derived them was extinct after that date; and the Cypriote syllabic signs must be older. Thus, though no known inscriptions can be placed before about 900 B. C., yet the forms must have started about the same period as that of the first of these towns, Kahun. The conditions that we find, therefore, of a great variety of signs in use, many of which have not survived, while others have drifted apart into many different alphabets, are just what might be expected at these early times. The apparent connection of these signs with some of the mason's marks of Egypt suggests that they may have been adopted by the foreign workmen from their Egyptian fellow-laborers; and the very lack of literary education among such men would lead to their forming alphabets of their own from such materials. We have at least now obtained two well-defined stages between the finished and segregated alphabets of the period of known inscriptions of 900 B. C. downward and the original elements of Egyptian hieroglyphs, hieratic, mason's marks, and perhaps Hittite and cuneiform characters, from which the alphabets were evolved. To discuss the historical descent of the signs, and to form a continuous theory of them, will need much discussion and more materials. Meanwhile, my work will lie in the complete gathering in of what may still remain in these towns. A full account and drawings of every sign and every object of importance found this year will appear in a few months.

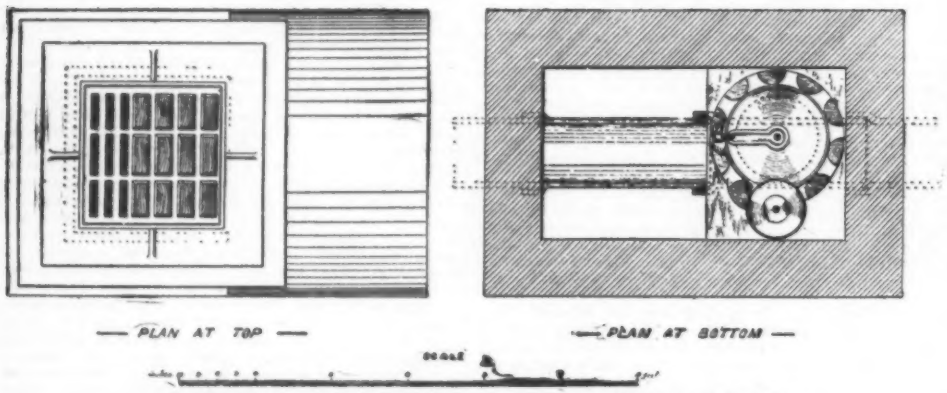
W. M. FLINDERS PETRIE.

REEVES' SYSTEM OF SEWAGE TREATMENT.

A VERY effective system of sewage treatment has been devised and perfected by Mr. R. Harris Reeves, and which we illustrate. It comprises the ventilation of sewers and the prevention of the generation of the sewer gas, the system being automatic and continuous in its action. The ventilation of the sewers is effected through the ordinary manhole. In the center wall of the manhole a recess is built to receive the apparatus, as shown in our engraving in the longitudinal section. The air in passing from the street into the sewer, or from sewer into the street, passes with a clear opening and without the slightest obstruction or friction through the apparatus. The apparatus for ventilation is of simple construction, containing chemicals which act simultaneously on the air in the sewers and on the sewage itself. It is made of chemical ware, and the right hand chamber shown on the transverse section is filled with sulphuric acid, and the left hand or larger chamber or cistern is filled with manganate of soda. This is placed in finely perforated trays. The cover of the manganate of soda chamber is a double one, and the inside part is also finely perforated, which allows the water to percolate through. The water enters at the top, percolates through the cover and the manganate of soda trays, thus forming the solution. This drops on a disk, as also does sulphuric acid. By this action a portion of the oxygen is set free from the manganate in the form of a gas, which keeps the sewers sweet and destroys any bad gas which may be made in such







REEVES' SYSTEM OF SEWAGE TREATMENT.

drains. The solution thus formed is permanganic acid, which overflows into the sewage from the bottom of the apparatus.

It will be thus seen that at every drop of the solution a fresh supply of oxygen is given to the air of the sewers and a disinfectant of the sewage is formed, which stops fermentation or decomposition, and prepares the sewage for further treatment in precipitation at the outfall works. At the outfall works, by this process, with additional apparatus, the precipitation is good and the effluent clear. We recently had the opportunity of inspecting the working of this system, which was shown to possess many advantages. It is in use with the best results at various places, notably at Frome, the engineer of which town reports that it is the best system that has been adopted. By the use of this system the escape of sewer gas from the manholes, or into the soil-pipes of houses, is impossible. It also prevents the escape of sewer gas from cesspools into houses. Where this system is adopted the use of tall ventilating shafts, or means for procuring the quick circulation of air in the sewers, is entirely unnecessary, and the cost is very much less.—*London Iron.*

[GARDEN AND FOREST.]

THE GREAT SEQUOIA.

THE first white man who set eyes on the *Sequoia gigantea* was probably Gen. John Bidwell, now one of the best known of the California pioneers. He has told me in a very simple and careful way the incident in his journey across the continent in 1841. He was a mere boy in years then, but a man in experience. The adventures of the party would fill a volume. All that concerns the Sequoias is to this effect. The explorers were on the summit of the Sierras, worn out and anxious to descend into the valley. They were in an Indian country; the game was very scarce, and Bidwell went ahead to hunt and explore the region. Late in the afternoon, while in the midst of the deep canons of Calaveras, and hastening to reach the river gorge to rejoin his companions, young Bidwell passed through the Calaveras grove of Sequoias. He was in such haste that he only noticed the immense size of the trees as he stood a moment beside one of the fallen giants. He said nothing of his discovery; but afterward, when in the employ of General Sutter, at New Helvetia, he planned an exploring party to find the great trees he had seen at dusk that afternoon in 1841. Other business delayed the expedition. Then came the war, the conquest of California, and the discovery of gold. Bidwell went first to the mines, and then was busy in securing his great Rancho Chico, and had no time to look for his big trees.

At last, in the spring of 1852, A. T. Dowd, a hunter of Murphy's Camp, Calaveras, while following a wounded grizzly, passed through the forests of *Pinus Lambertiana* and *Pinus ponderosa*, and came upon the giant Sequoia grove, since so famous. He was laughed at when he told his story; but the next Sunday he rushed wildly down the hill and called to "the boys" that he had "shot an enormous grizzly." They went with him to the base of the largest tree in the grove: "There, boys," he said, "is my grizzly!" When General Bidwell heard the story of the discovery, he said at once: "Those are my big trees; I am very glad they have been found."

The California Academy of Sciences received specimens of foliage, bark, and cones of the Sequoia from the Calaveras grove before June, 1852. The late Dr. Kellogg forwarded specimens to Professor Asa Gray and to Dr. John Torrey, who at once recognized a second species of Sequoia. Veitch had some time before sent William Lobb, as a collector of plants, to the Pacific coast. He was then at Monterey, I think, with Dr. C. C. Parry. Dr. Kellogg told him about the Sequoias, and he procured specimens for Dr. Lindley, who, failing to understand its true relationship, described the tree in the *Gardener's Chronicle* of December 24, 1853, as Wellingtonia—the name by which it is still almost universally known in English gardens.

When I was in Fresno, two years ago, I was told by the proprietor of the leading newspaper of the county that he had just returned from the redwood forests in the Sierras, and that there were thousands of acres of timber waiting to be taken up. "It is better timber than the redwood of the Coast Range," he said, "and constitutes one of the great resources of Fresno and Tulare Counties. There are several mills at work in the forests, and we shall have a narrow gauge railroad there in a few years." I followed further into the matter, and discovered that the redwood referred to was the largest and finest forest of *Sequoia gigantea* in California, and that it was rapidly passing into private ownership and was being cut into lumber and split into fence posts. During the past two years the destruction of these forests has gone on with accelerated speed, owing to the rapid settlement of the foothills by farmers, who are far removed from the railroad, and find it cheaper to get *Sequoia gigantea* redwood from the mountains than *Sequoia sempervirens* redwood from the coast.

There are ten groups of *Sequoia gigantea* in the Sierra Nevada Mountains, and the descriptions of most of them are found in the writings of Muir, Whitney, and Clarence King. Beginning at the north, these groups are named as follows: The Calaveras grove, the South Calaveras grove, the Tuolumne grove, the Merced grove, the Mariposa grove, the Fresno grove, the Dinky grove, the King's River grove, the new King's River grove, and the large Kaweah groves. The latter consists of a number of small Sequoia forests extending over a belt of country five miles wide and fifty miles long. It is in this region that the Kaweah colony of socialists have secured most of the timber lands, and are now building large mills. It is not probable that in ten years any of these ten forest groups will remain except the Calaveras groves, and perhaps one or two other small groups, now used as summer resorts, unless immediate steps are taken to prevent the further filings of timber claims. The records at the land office show that in the past twenty-two months 131,680 acres of heavily timbered land have been bought from the government, much of it obtained by a systematic evasion of the laws. Four-fifths of this land has been taken up along the western slope of the Sierra Nevada, and includes most of the *Sequoia gigantea* districts.

The Calaveras grove covers fifty acres, and contains ninety-three large trees. One tree in 1854 was stripped of its bark to a height of 116 feet by a man who thought he could make a fortune exhibiting it. The speculation, fortunately, failed, or the grove would have been ruined by similar enterprises. This tree is estimated to contain 537,000 feet of marketable lumber, and stands 325 feet in height, girthing 84 feet without the bark. A fallen tree was about 400 feet in height, and the circumference of the trunk near the base is 110 feet. The south grove contains 380 Sequoias of good size—some very large. One of the largest of the standing trees in the Calaveras groves is the "Grizzly Giant," 33 feet in diameter near the ground. There is a tree in the Kaweah region that is 36 feet in diameter, and there may be even larger ones.

The Giant Sequoia yields seeds in such abundance (Mr. Bradley counting 324 seeds in a small cone) and the vitality of fresh seed is so uniform, that millions of trees could be grown and planted on the mountain slopes of California. In the Sacramento, San Joaquin, Sonoma, Santa Clara and other large valleys the tree thrives without especial care. In most places it has grown faster than the *S. sempervirens*. If the State were to undertake to reforest the waste lands, the Giant Sequoia would offer one of the best trees for that purpose. The reason why it now grows only in such isolated and small groups, instead of in extensive forests, is because its small, light seeds cannot easily root themselves on the dry, leaf-covered soil of the region. The climate has changed; the tree is slowly disappearing. Whenever mountain fires or cloud bursts have swept away the thick layer of coniferous leaves and scales from the ground, young Sequoias have sprung up. This tree, like the Monterey cypress, has every element of vitality but one—its light, thin seeds are not adapted to survive under the present climatic conditions. The successful type of tree seed is that of the *Pinus Sabiniana*, which holds its own so well on the hot foothills of California. The Great Sequoia lacks the capacity of *S. sempervirens* to reproduce itself from suckers from the roots, and if it is ever to become an important factor in the timber supply of California, its seeds must be planted under favoring conditions. None of the Pacific coast conifers is more easily grown when the seeds are sown in moist soil.

Another illustration of the dangers to which some tree seeds are subjected may be found in the case of *Eucalyptus globulus*. Groves of this tree were planted on the dry California hillsides twenty years ago. They now perfect millions of seeds, but the seeds never grow; they never reach the surface of the dry, leaf-covered soil, or insects carry them off. But many pounds of this seed are gathered by the nurserymen, and sown with better results than with imported seeds. In the moist valleys the Eucalyptus grows from self-sown seeds, but never on hillsides. Yet seedlings three months old are fit to plant anywhere. Without replanting, the Eucalyptus forests of California will mostly disappear in the course of time, just as the Sequoias are disappearing.

The guide books to the Calaveras and other groves still place the age of the Sequoia trees at between three and four thousand years. Professor Whitney's count, it may be remembered, gave a result of 1,255 years. Mr. Bradley made a careful study of the same tree, counting the two ends of the lowest section of the trunk, eighteen feet apart. His results were 1,240 and 1,226. This is a mature tree, fifteen feet in diameter. A large specimen of *Sequoia sempervirens*, 1,200 years old, measured eleven feet in diameter.

Mr. Bradley takes the Pavilion tree, which Whitney first measured, divides the cross section into annular zones of one hundred rings, and computes the area of each zone. In this way he arrives at the wood growth for each century. He assumes that 300 years brought the tree to its full height. His ratio of volumes of growth for twelve centuries, the maximum being 1,000, then becomes as follows: 77, 308, 557, 963, 1,000, 794, 841, 908, 828, 817, 907, and 938. The fourth and fifth centuries may be supposed to mark the period of expansion of the head, after the tree had reached light and air above the surrounding forests.

San Francisco. CHARLES HOWARD SHINN.

THE EARTH NOT A VAST CEMETERY.

AGAIN and again this old poetic fancy of the earth as one great cemetery buried several times deep with dead men and women and children has been refuted by figures. But great is error and it will prevail, unless the truth be well and steadily upheld. The population of the earth is now about 1,500,000,000. Suppose the human race to have existed for 6,000 years, and to have been always as great as now. In 6,000 years you have 60 centuries. In each century you may count three generations of mankind, or one hundred and eighty generations in all, each being a generation of 1,500,000,000. Now lay out a cemetery for one generation. It will be a huge estimate to give to every man, woman, and child a grave five feet by two, or ten square feet. You want for your graveyard, then, 15,000,000,000, square feet of ground. A square mile contains something less than 28,000,000 square feet. You want, then, a graveyard not 55 miles long by 10 wide for your whole generation. Now multiply this

by 180 and you have your burial ground for 6,000 years of mankind. That is, a strip of land 1,800 miles long by 55 miles wide will be ample. In other words, a cemetery containing 100,000 square miles would be sufficient for the entire human race to lie side by side. The estimate which I have given you of continuous population is obviously enormously large. The estimate of the size of each grave is very large. A strictly correct estimate would reduce the size of the required cemetery more than one half. But enormous as it is, you could lay out your burial ground for all men who have lived on earth, so that they could lie side by side, in Arizona or in California, or you could lay it out in Texas large enough to accommodate the race of 6,000 years past and also the race for 6,000 years yet to come, all sleeping in the soil of that one State of this Union. But some one says the race of man has been on earth 100,000 years. That is a pure imagination, and there is not, so far as I know, a fact on which to rest it. But suppose it is true and suppose the population always what it now is. You have provided for 6,000 years of it. You want nearly 17 times as large a cemetery for the generations of a thousand centuries. That is, you want 1,700,000 square miles in it. Lay it out whenever you please, 1,700 miles long by 1,000 wide. It is but a part of the United States. And so enormously large have been the rough estimates thus far used, it is safe to say that if the human race has been in existence 100,000 years, a separate grave could be provided for every individual of the race within a part of the United States east of the Mississippi River. The fact is, my friend, you need but a very small piece of the earth's surface to lie down in. And you occupy but a very small space while you live. Stand in a corner, with your back to the wall, and your shoulder against the side wall. Put a book against the wall outside your other shoulder close to it. Let some one hold a stick across in front of your body. So you will measure how much room you occupy when standing up in a crowded assembly. You are a large man if you require two square feet. The average requirement of a generation of men, women, and children is not one square foot and a half. More than 18,000,000 persons can stand on a square mile of surface. Now see how small a crowd after all would be an assembly of all men out of all ages and kindreds and peoples, were they gathered together. Carry your arithmetic still further. You laid out a cemetery for the 1,500,000,000 of mankind now living. Build a city for them to dwell in. Average families at five persons to a family, and give each family a house and lot 20 feet by 100. Your cemetery gave five persons 50 square feet for graves. Their city lot is forty times as large. Your city must therefore be forty times as large as your cemetery. Add 20 per cent. for good streets. I will not save you or your school-going child the trouble of "doing the figures." Impress the truth on your mind by three minutes' work with pencil and paper, that the whole living human race could be gathered in a city so small in comparison with what you have imagined. And now remember that all the estimates on which we have gone are too large. This city lot might as well be 20×50. People live in flats without back yards, and in stories one above another. Your city modeled after the latest fashions in cities need not be a quarter the size our estimates have made it. When you have built your city, inquire, and be surprised to find the vast space for garden, fields and forests you have left accessible to it, whence could come all the necessities and luxuries of civilized life.—*W. C. Prime, LL.D., in the New York Journal of Commerce.*

[REPORTS FROM THE CONSULS OF THE UNITED STATES.]

COOKERY FOR WORKINGMEN'S WIVES.*

Report by Consul UNDERWOOD, of Glasgow.

FISH.

Fresh Herring, Baked.—Fresh herring, salt, pepper, vinegar, and dripping.

Clean the herring well, pack them in a baking dish, sprinkle salt and pepper over them, a little dripping, and two teaspoonfuls of vinegar. Bake half an hour. Serve hot. Good cold.

To Fry Herring.—Clean and dry the herring, put some salt, pepper, and oatmeal on a plate; dip each herring well in the mixture; have a frying pan hot with some dripping in it, put in the herring and fry, turn carefully, and fry the other side. Serve hot.

Another Way to Fry Fresh Herring.—Cut off the head, fins, and tail, split them up the back; clean well; take out the backbone, scrape them, salt and pepper the inside. Take two herrings, place the insides together flat, dip them in oatmeal, and fry for about eight minutes over a clear fire in a frying pan.

To Boil Fresh Herring.—Wash, gut, dry, and rub them over with a little salt and vinegar; put them into boiling water with a tablespoonful of vinegar, and simmer for ten minutes. When done, take them out of the water immediately. If they are to be kept hot for some time, cover them with a clean cloth.

To Boil Salt Herring.—If very salt, leave them to soak in cold water for some hours. Put them on to boil in cold water, and let it come slowly to the boil. When boiling, draw to the side of the fire, and keep at the boil for ten minutes, and take them from the water the moment they are cooked. If salt fish are allowed to boil, it hardens them.

Baked Sprats.—Sprats, dripping, parsley, salt, pepper, and vinegar.

Clean and wipe the sprats gently; mix a tablespoonful of chopped parsley, a teaspoonful of salt, and half a teaspoonful of pepper on a plate; dip in each sprat, and put in a baking dish, with a little vinegar and a little dripping on the top, and bake for half an hour. Good hot or cold.

Fish Pie.—Cod head, 1d.; one-fourth stone potatoes, 1½d.; one pound flour, 1½d.; one-fourth pound lard, 1½d.; baking powder, ¼d.; total, 5½d.

Get a large cod head, wash it well, place it in a pie dish, and put the dish into a pot with water; but do not allow any of the water to get into the pie dish. The head is to be cooked by the steam. Let the water boil hard for half an hour, then take out the head and remove all the meat from it; boil and slice one-fourth stone of potatoes, put a layer of potatoes into the pie dish first, then fish, pepper, salt, till all are in, adding only any of the liquid that was in the pie dish, then cover with paste.

Salt Cod Fish Cakes.—Two pounds of cod fish, one-fourth stone potatoes, one egg, pepper, flour, and dripping.

Soak the fish overnight. Put it on to boil. Whenever it boils draw it to the side, and let it steam (salt fish should never be allowed to boil, for it only hardens it). When done take out all the bones; have your potatoes boiled; mash them and the fish together, with peper and salt to taste. Beat up the egg and add it. Make into thin cakes, flour them, and fry them, with dripping, a light brown. Fresh fish can be done in the same way, and is more nutritious.

Fish Cooked in its Own Juice.—One pound fish.

Have your fish well cleaned, wipe it well, and put into a jar with a clove or sprig of parsley; cover very close, and set it in a saucepan of boiling water, keeping it boiling for half an hour. Serve on a hot plate, with or without sauce.

Fried Fish.—One pound fish, one-fourth pound dripping.

Put the dripping on the fire in a pan to get hot; have the fish cleaned and wiped, cut off fins and tail, sprinkle it lightly with bread crumbs, or flour, or meal; shake off any loose crumbs. Put a crumb of bread into the dripping to see if it is hot enough; if it hisses, it is ready; if it burns, it is overdone. Put in your fish; it will take about ten minutes to fry; have it a nice color. Serve on hot plate. (If you can afford it, you can dip it in egg before you put it in bread crumbs).

To Boil Fish.—If the fish is large, with skin whole, it must be placed on the fire in cold water; if it weighs 3 or 4 pounds, it will take thirty minutes to boil. To every quart of water put a teaspoonful of salt, and when the fish begins to boil, remove the lid to one side and let it simmer gently till quite done. Have only enough water to cover the fish, or the skin will crack and spoil its appearance.

Steaks or Sliced Fish.—To every quart of water add a teaspoonful of salt. When the water boils, add the fish and allow it from fifteen to twenty minutes for each pound. A tablespoonful of vinegar in the water is an improvement to fish.

PUDDINGS.

Boiled Scrap Bread Pudding.—Any odd pieces of bread. Put into a bowl, pour boiling milk over them; let them stand till well soaked, then beat up with a fork; add a small piece of dripping, a few currants or raisins, a little moist sugar; mix well up; put into a greased bowl, tie a floured cloth over the top, and boil for an hour. Good either hot or cold.

Plum Pudding for the Million.—One-half pound chopped suet, one-half pound flour, one-half pound bread crumbs, 1 pound grated carrots, 1 pound potatoes, 1 pound currants, 1 pound raisins, 1 pound apples, 1 teaspoonful of allspice, 1 teaspoonful of ginger, 1 teaspoonful of cinnamon, 1 teaspoonful of baking powder, half a nutmeg (grated), 1 pound sugar, a good pinch of salt.

Mix the flour, bread crumbs, suet, carrots, potatoes, ginger, cinnamon, allspice, nutmeg, baking powder, salt and sugar well; then add currants, raisins (stoned and cleaned), and apples. Mix with water or milk into a soft paste, boil in floured cloth for four hours, or in a basin or mould for five hours. Good.

Brown Suet Pudding.—One pound flour, one-fourth pound suet, one-half pound treacle, one-half pound raisins, salt, half nutmeg (grated), 1 teaspoonful cinnamon, 1 teaspoonful soda, 1 teaspoonful cream of tartar, milk.

Warm the treacle, chop the suet very fine, mix the flour with a pinch of salt, soda, cream of tartar, nutmeg, cinnamon, all well together; add treacle, suet, raisins, and put in a well-floured cloth and boil quickly for three hours.

Fig Pudding.—One pound figs, one-half pound flour, one-half pound bread crumbs, one-fourth pound suet, 2 ounces sugar, half a teaspoonful nutmeg, 1 teaspoonful cinnamon, 1 small teaspoonful baking powder, milk or water.

Chop the suet and figs fine; mix flour, bread crumbs, sugar, cinnamon, nutmeg, and baking powder well together; add suet and figs, with enough milk or water to make into dough. Roll it into a floured cloth, leaving room for it to swell, and boil very fast for three hours.

Indian Pudding.—One quart milk, one-half pound Indian meal, 1 small cup treacle, 1 tablespoonful dripping, 1 teaspoonful ginger, 1 egg, 1 teaspoonful baking powder, a pinch of salt.

When the milk is nearly boiling, wet the meal with some of the cold milk and let it boil; then add the treacle, dripping, ginger, pinch of salt, and egg well beaten; lastly, the baking powder. Turn it into a pie dish and bake for two hours.

Cottage Pudding.—One cup milk, 1 teaspoonful (large) butter, 1 teaspoonful sugar, three-fourths pound flour, 1 teaspoonful soda, 1 teaspoonful cream of tartar, yolks of two eggs.

Mix sugar, yolks of eggs, and butter to cream; then add the milk and flour by degrees; beat very light, then add soda and cream of tartar, and bake for one hour.

Sauce.—Half a cup of milk, stir in two tablespoonfuls of sugar, beat the whites of two eggs to a slight froth, and stir in; flavor with vanilla before serving.

Swiss Pudding.—One pound apples, 2 tablespoonfuls stale bread crumbs, 1 egg, 3 ounces sugar, 2 teaspoonfuls butter, or dripping.

Peel, core, and slice the apples and stew in a covered jar; when done add the sugar and a teaspoonful of butter; when cool, stir in the egg, well beaten; butter the pie dish; strew bread crumbs about an inch thick at the bottom, and as many up the sides as will remain on; pour in your apples, and strew over them the remaining crumbs, and bake for one hour.

Rhubarb or Apple Dumpling.—One pound flour, one-fouth pound suet, 2 pounds apples, or rhubarb, 6 ounces sugar, 1 teaspoonful baking powder, one-fourth teaspoonful salt; if apples, two cloves; if rhubarb, half the skin of a lemon, or a little ginger.

Chop the suet fine, and mix it with the flour, salt, and baking powder; then add a little water till you have a nice, stiff paste. Roll out enough of the paste to line your dish, both bottom and sides. Peel and core the apples, cut them into six slices. If it is a rhubarb dumpling, cut the rhubarb in 1 inch lengths, and put it into the basin with the sugar and flavoring; then take the remainder of your paste and roll it out the size of the top of the basin, wet the edge of the paste lining and lay on your paste cover so that it will stick to it; then flour your cloth and tie it up. Have the water boiling; boil your dumpling for three hours, and turn it out.

A Good Tapioca Pudding.—Soak 3 tablespoonfuls of tapioca in some ginger wine for one hour; then add a little sugar, 1 beaten egg, and some milk. Grease a dish, pour it in, and bake for one hour.

Sago can be made in this way, also bread and butter pudding; using more wine, with a little water and no milk, is a nice change.

Simple Trifle.—Six sponge cakes, 2 eggs, 1½ tablespoonfuls jam, 1½ breakfast cupfuls milk, 1 teaspoonful sugar.

Cut sponge cakes in slices and arrange neatly in a pudding dish; pour a little milk over them, just enough to make them soft, then spread the jam over. Take the eggs and separate the whites from the yolks; lay aside the whites; beat up the yolks in a bowl; put sugar and a breakfast cupful of milk into a small pan and bring it to the boil; then pour this over yolks, stirring all the time with a fork; return it to the pan, and stir over the fire till it thickens a little (it must not boil, or the eggs will curdle), then put spoonfuls lightly over the sponge cakes. Whisk up the whites with a knife into a stiff froth, and lay lightly on the top. Stale sponge cakes are very good for this pudding, and are to be had cheaper on Saturday night.

Marmalade Pudding.—One breakfast cupful of flour, 1 breakfast cupful bread crumbs, 2 ounces suet, 1 teaspoonful baking soda, 1 tablespoonful sugar, 3 tablespoonfuls marmalade, butter, and milk.

Chop suet fine, and put in a basin, add bread crumbs, flour, sugar, soda, and marmalade; mix with a little buttermilk till the whole is wet (it should not be very moist), and beat up a little with a fork; grease a bowl, put in the pudding, and cover with a greased paper; put the bowl into a pot with an inch of boiling water in it; put the lid of the pot closely on and steam for two and a half hours.

This pudding can also be made with sirup, instead of marmalade.

Christmas Pies (Simple).—One-half pound of apples, one-fourth pound figs, one-fourth pound currants, one-fourth pound raisins, one-fourth pound sugar, one-half ounce cinnamon, one-half ounce ginger, 1 pound flour, one-fourth pound lard, 1 teaspoonful baking powder.

Peel and core the apples, and cut them into small dice, put them in a basin with the sugar; mince the figs fine; stone and mince the raisins (or use sultana raisins); pick and rub the currants very carefully with a cloth; put all into a basin with the apples and sugar, add the cinnamon and ginger (and any other flavoring that is liked). Mix all well together (the mince is all the better for being prepared some time before it is wanted).

For the crust, mix the flour, lard, a teaspoonful of baking powder, and a pinch of salt, well together, then add enough cold water to make a stiff paste; roll out to about a quarter of an inch thick. The pies can either be made in small tins or soup plates. Rub the tins or plates well with lard, cut the pastes to the right size, put the mince meat in carefully, wet round the edges, and cover the top with paste, and bake in a not too quick oven.

Jam Roly.—One breakfast cup of flour, 1 breakfast cup of bread crumbs, 2 ounces suet, 1 pound jam, 1 tablespoonful of sugar, a small teaspoonful of baking soda.

Put in a basin the flour, bread crumbs, suet chopped very fine, soda, and sugar, and mix with cold water into stiff paste, and roll out into a thin sheet about one-fourth inch thick; take a bowl and grease it with dripping, line it with some of the paste, spread at the foot of the bowl some jam; then lay in a layer of paste, repeating layers of jam and paste, till the bowl is filled; wet the edges of the last layer of paste, and turn down over the lining of the bowl, cover the top with a greased paper, and put the bowl into a pot with half an inch of boiling water in it; put the lid of the pot close on, and steam for two hours, then turn out.

This pudding is very good made with apples instead of jam.

A Few Hints on Pudding Making.—When a pudding is to be boiled, see that the cloth to be used is very clean, and that it is dipped in boiling water, dredged with flour, and shaken well before the pudding is put into it.

If a bread pudding, it must be tied loose. If a batter one, it must be tied tight.

When a shape or basin is to be used, it must be well greased before the pudding is put in. When it is ready, care must be taken in lifting it out. Allow it to stand for a few minutes before unloosing the cloth.

All puddings must be boiled in plenty of water, turned frequently, kept closely covered, and never allowed to go off the boil.

If the pudding is to be baked, the dish or pan must be also greased before it is put in. Bread and custard puddings require time and a moderate oven to raise them.

As a rule, steamed puddings are put in an earthenware dish, covered with a tight cover or greased paper, which is placed in a pan of boiling water, which must not come more than three parts up the sides of the pudding dish. If the water boils away, more boiling water must be added, and it must be kept always boiling. Be careful in removing the lid that no drops fall on the pudding. Puddings, etc., when steamed, do not require so much liquid in them as when baked. The dry air of the oven dries them, steaming keeps them moist.

Plain Bread Pudding.—Any odd pieces of crust or crumbs of bread will make a nice pudding. To every quart allow half a teaspoonful of salt, 1 teaspoonful of grated nutmeg, 3 ounces of sugar, half a pound of currants, and half an ounce of butter.

Break the bread into small pieces, and pour as much boiling water over it as will soak it well. Let this stand till the water is cool; then press it out, and mash the bread with a fork until it is quite free from lumps. Measure this pulp, and to every quart stir in salt, nutmeg, sugar, and currants, in the above proportions; mix all well together, and put in a well buttered pie dish. Smooth the surface with the back of a spoon, and place the butter in small pieces over the top; bake in a moderate oven for one and a half hours,

*Continued from SUPPLEMENT, No. 732, page 11709.

and serve very hot. Boiling milk substituted for boiling water would very much improve the pudding.

Oatmeal Pudding.—One-fourth pound suet chopped fine, one-half pound oatmeal; 2 onions chopped fine, a teaspoonful salt, and half teaspoonful pepper; mix well together without water; tie it rather loosely into a floured cloth, and boil for three hours.

A cheap dish, and eaten with bread or potatoes. Good and nourishing.

Suet Crust for Pies or Puddings.—To every pound of flour allow one-fourth pound of beef suet, half a pint of water, half a teaspoonful of salt, and a teaspoonful of baking powder.

Free the suet from skin, chop it extremely fine, and rub it well into the flour, with salt and baking powder, add the water, and work the whole into a smooth paste, roll it out, and it is ready for use.

The above, with the addition of treacle or fruit, and rolled up as a rolly poly in a flour cloth, and boiled for three hours, is very good.

Apple Sauce.—One pound of apples, peeled, cored and cut in thin slices. Stew with 1 ounce sugar, half a teacupful of water. Stew till in a pulp, and serve with roast pork, etc.

Mint Sauce.—Chop a good handful of green mint up fine, put into a bowl with a large tablespoonful of brown sugar, half a teaspoonful of salt, a quarter teaspoonful of pepper, and a teacupful of vinegar. Serve with cold meat or lamb.

Brown Sauce.—One ounce butter, 1½ ounces flour, half a teaspoonful of salt, a quarter teaspoonful of pepper, a tablespoonful of vinegar, and a small onion.

Put the flour before the fire till it is a pale brown, put the butter and onions, cut fine, into the pan, let it get pale brown; add the flour made smoothi n a cup of water, a little pepper, salt, vinegar, and another one-half cupful of water, boil and drain.

White Sauce.—One ounce butter, 1½ ounces flour, half a teaspoonful of salt, a quarter teaspoonful pepper. Mix together in a pan, add the milk gradually (about two teacupfuls), let it boil, and serve for fish or vegetables. For mutton sauce, add to the above a handful of parsley washed well and chopped very fine.

Pudding Sauce.—Two teacupfuls of milk, half a cup of sugar, 2 eggs, a tablespoonful of vanilla. Beat eggs to a froth with sugar. Boil milk and sugar, pour over them, stirring all the time, add vanilla.

Plain Pudding Sauce.—One tablespoonful corn flour, large tablespoonful sugar, teacupful milk, and 1 egg. Beat egg, sugar, and corn flour, with tablespoonful of milk, very light, boil the rest of the milk, pour it over the mixture, stirring all the time.

Preserved Rhubarb.—Wipe the stalks of young rhubarb, cut in neat pieces. To every pound of rhubarb add 1 pound of sugar and the grated rind and juice of 1 lemon. Put sugar and lemon on the fire to melt; when melted add rhubarb. Boil for half an hour, taking care not to break the rhubarb. Take it out carefully, put it in jars, let it cool, then cover with paper, and put away for winter use.

To Preserve Rhubarb for Winter Use.—Rub the rhubarb well with a damp cloth to take off any sand, dust, or smoke. When perfectly clean cut it into nice pieces about an inch long, and put them into a deep earthenware dish. To every 6 pounds of rhubarb add 6 pounds of sugar and one-fourth pound of best whole ginger. Cover the dish and let it stand for two days. Then run off the sirup into a preserving pan and boil it for half an hour; then add the rhubarb and boil until it is clear; when it is transparent it is done. Stir it as little as possible, so as not to break the rhubarb (it looks best whole). This preserve will keep for a year.

Apple Jelly.—Two pounds apples, 2 pounds rhubarb, 2 lemons, and sugar.

Wipe clean and quarter the apples, remove any decayed pieces, keep in the seeds. Wipe the rhubarb clean, and cut it up into small pieces; wipe and peel the lemons very thin; put all in jelly pan, and just cover with water, add the juice of the lemon, and boil to a mash. Then pour into a jelly bag, and let it drain; measure the juice, and to every pint add 1 pound of sugar. Put the jelly pan on the fire, and bring it to the boil, stirring until all the sugar is melted. Let it boil for twenty-five minutes, them skim and pot.

Lemonade with Citric Acid.—One pound sugar, 1 pint of water, 1 ounce citric acid, two teaspoonfuls essence of lemon.

Put sugar and cold water in saucepan and boil. Let it cool; then add the other ingredients, and bottle. A tablespoonful to a tumbler of water.

Sherbet (a refreshing drink).—One-half pound of sugar, one-fourth pound tartaric acid, one-fourth pound carbonate soda, sixty drops essence of lemon.

Mix sugar and essence of lemon, and dry thoroughly. Then pass all through a sieve. Bottle and cork tight. For a tumbler of water use a teaspoonful of the mixture.

Boston Cream.—One pound brown sugar, 2d. worth essence of lemon, 2 ounces tartaric acid, the white of 1 egg.

Put the sugar into 3 quarts of cold water, boil it, pour into a basin, and let it cool. Add the essence of lemon, tartaric acid, and the white of the egg well beaten up. Bottle. One tablespoonful of this sirup to a tumbler of cold water.

Ginger Wine.—One-fourth ounce essence of cayenne, one-fourth ounce essence of ginger, one-half ounce tartaric acid, 1 lemon, 1d. worth burnt sugar, 3 pounds sugar, 3 quarts water.

Put 3 quarts of cold water into a preserving pan, with the rinds and juices of lemon, the tartaric acid, and the sugar. When melted take any scum off; let it boil. When cold add the essence of cayenne and of ginger, and add sufficient burnt sugar to give the color you wish. Bottle tight, and it will keep good for three months.

Raspberry Wine.—One-half ounce essence of raspberry, one-fourth ounce essence of cayenne, one-half ounce tartaric acid, 1d. worth cochineal, 4 lemons, 4 pounds sugar, and 3 quarts water.

Put on the water with the juice and rinds of lemons, sugar, and tartaric acid; let it boil; take off all the scum. When cold, add the essences, and a few drops of cochineal to give the desired color. Bottle tight.

Apple and Tapioca Tart.—One pound apples, one-fourth pound tapioca, one-fourth pound sugar, 3 cloves.

Soak the tapioca all night in cold water. Peel, core, and slice the apples. Put a layer of apples in a pudding dish, then one of tapioca. Sprinkle in some sugar and cloves, and continue this process till all is in.

Cover: Three-fourths pound flour, 3 ounces lard, 1 teaspoonful baking powder. Mix flour, lard, and baking powder, with a pinch of salt, well together; then add water to make a stiff paste, roll out, cover, and bake for an hour and a half.

In the spring rhubarb is very cheap and wholesome, and may be used instead of apples.

Suet can be substituted for lard or dripping, and made into a rolly poly, and boiled for two hours.

(To be continued.)

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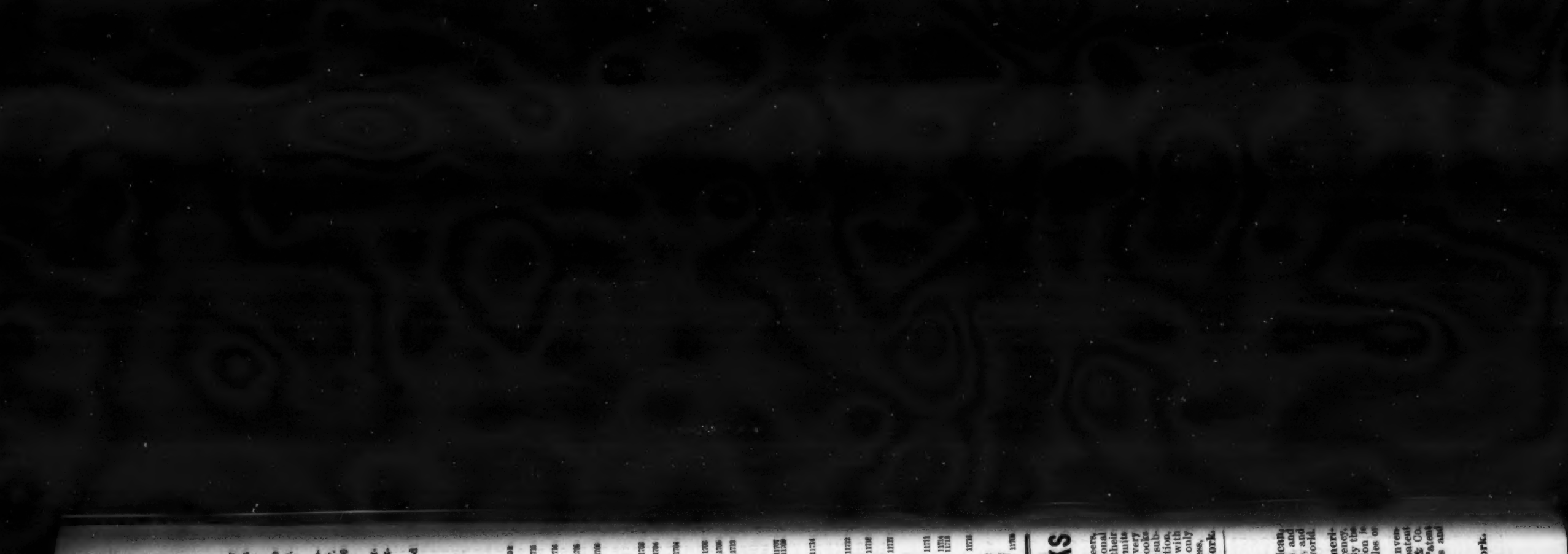
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